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JAN 78 T W BUTLER, D F COTTRELL, W M MAYNARD F30602-76-C-0337
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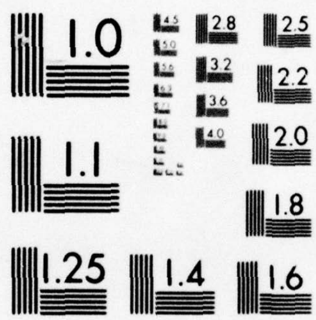

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FAILURE RATE MATHEMATICAL MODELS FOR DISCRETE SEMICONDUCTORS

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Martin Marietta Corporation

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This study revises and updates the appropriate sections of Military Handbook 217B, "Reliability Prediction of Electronic Equipment," pertaining to semiconductor devices, section 2.2. More than 200 billion part-hours of field operating data were collected and analyzed during the study effort. Significant revisions were made to environmental factors and some quality factors.

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SUMMARY

This report describes the results of a 16-month program conducted by Martin Marietta to revise the discrete semiconductor device sections of MIL-HDBK-217B, "Reliability Prediction of Electronic Equipment." This report summarizes the data collected and the revisions to the handbook failure rate models; the actual revision sheets to be inserted into the handbook are provided as an addendum to this report.

More than 200 billion part-hours of operating data were collected in nine different enviromental application catagories. The data were obtained as a result of an extensive collection program that included the survey of private contractors, government facilities, and research institutions throughout the country. The collected data were grouped, analyzed, and statistically tested for homogeneity before being combined into a normalized data base. In the process, approximately 50 percent of the collected data were deleted from the data base because it was either incomplete or nonhomogeneous. Table 1 on page 7 reflects the total operating part-hours by group and part type that were finally included in the data base.

Within the part type groupings as shown in Table 1, the data were organized into groups of similar environmental factor, π_E, and then into subgroups of similar quality factor, π_Q. A weighted average, basic failure rate was then calculated from the field data and modified by the existing π factors of MIL-HDBK-217B. A predicted failure rate was then selected from the applicable basic failure rate matrix charts of MIL-HDBK-217B at the average temperature and stress ratio of the data subgroups. All averages were weighted according to the number of operating part-hours of the data elements.

The factored field data failure rates were then compared to the predicted basic failure rates and a variance ratio calculated. This variance ratio was compared for many different combinations of data groups in search of definite patterns that would indicate the need to modify specific π factors or basic failure rates.

A general, across-the-board reduction in observed failure rate was the most significant result of the analysis. This appears to be predictable since semiconductor manufacturers are continuously advancing the technology for improved device quality. Introduction of TX and TXV requirements for semiconductor quality have tended to infuse higher quality into JAN and even commercial grade devices within the same manufacturing facility.

Martin Marietta recommends that MIL-HDBK-217B be modified to include:

1 Changes in environmental condition classifications to include separate factors for fighter, or supersonic, high performance, tactical aircraft versus transport or subsonic patrol and cargo aircraft. Also establishment of appropriate quantitative values for these factors.

2 Reduction of the quantitative value of the π factor for naval sheltered environment.

3 Reduction in value of the quality level π factors for semiconductor groups I through V.

These changes are summarized in Tables 4 and 5.

PREFACE

This final report was prepared by the Orlando Division of Martin Marietta Corporation for the Rome Air Development Center (RADC), Griffiss Air Force Base, New York, under Contract F30602-76-C-0337. The purpose of the contract was to revise and update MIL-HDBK-217B, section 2.2, that covers discrete semiconductors, excluding microwave devices (f_o > 400 MHz).

This report is CDRL Sequence Number A002 (CLI 0003) and covers the period from July 1976 to November 1977. The original termination date of the study was August 1977; but because of delays encountered in the acquisition of data required for the effort, the study completion date was extended to November 1977 at no additional cost to the government. The RADC Project Engineer was Mr. Lester J. Gubbins (RBRT).

In addition to Messrs. Butler, Cottrell, and Maynard, other contributors to the acquisition and analysis of data were: Brad Olsen, George Guth, Edwin Kimball, Thomas Kirejczyk, Neil Owen, Lynn Mercer, Aaron Penkacik, Betty Thomas, Lynn Westling, Robert Whalen, and Thomas Young. Overall guidance was provided by Messrs. William Carpenter, Robert Eldredge, and Thomas Gagnier.

CONTENTS

1.0 INTRODUCTION

Discrete semiconductors continue to be used in significant quantities in new electronic equipment, and their large population can have a definite impact on total equipment reliability. As reliability prediction plays an important role in the early conceptual definition of new equipment and in the planning for its operational support, it is necessary to continually assess the validity of reliability prediction models and methods. Therefore in July 1976, Rome Air Development Center awarded Martin Marietta Contract Number F30602-76-C-0337, entitled "Failure Rate Mathematical Models for Discrete Semiconductors".

This study consisted of an evaluation of the existing failure rate prediction models of MIL-HDBK-217B when compared to currently experienced field operating data. Where significant variances were detected, recommended changes to the existing models were defined in order to reconcile predictions with observed results.

This report describes method of evaluation, the results and conclusions of the engineering study, and includes as an addendum revised pages to update section 2.2 of MIL-HDBK-217B.

2.0 DATA COLLECTION

To provide a data base for the study, a data collection effort was initiated upon contract award. This effort included a survey of industry and government agencies for recent field operating data on semiconductor devices and a literature search for published information in journals, reports, seminars, etc.

2.1 Data Survey

A list of potential data sources was generated from previous study contracts, Government-Industry Data Exchange Program (GIDEP) memberships, and from sources suggested by RADC. A total of 560 private companies and government agencies identified as potential data sources were sent a data survey letter. Responses were received from 260 - approximately 46 percent. Each survey sheet was reviewed to determine if the data were applicable to this study. After this initial screening, the remaining respondents were contacted by telephone to discuss the data in more detail and to determine the availability of the data. Where possible, the data were mailed directly to Martin Marietta. In those cases where significant data retrieval was possible, visits to the data sources were arranged. During these visits, the operational data were jointly reviewed, reduced as necessary, and brought back for further analysis. Component failure was defined as the inability of the component to properly perform its intended function, resulting in its being repaired or replaced. Whenever detailed failure information was available, all secondary failures, premature removals, procedural, and personnel errors were consored.

Since most data obtained listed only the quantity of failures and experience with no elaboration of failure modes and mechanisms, much of the data are dependent upon each source's ability to properly categorize its equipment failures. As a result of direct contact with most of the sources, however, it is felt that the majority of data contributed to this study were properly screened by the contributors. As an additional check, a statistical outlier test was performed on the data, and any data that deviated significantly from the majority were eliminated. Therefore a high degree of confidence has been developed, which warrants the practical application of these data.

Data collection visits were made to 47 data sources on 5 separate trips to the Northeast, Midwest, Southwest, southern California and northern California. Most of the useful data for this study were obtained from these data collection visits. A summary of data sources contributing to this study is contained in Appendix A. Table 1 summarizes total part-hours by group and part type after data screening as described in paragraph 3.1.

2.2 Literature Review

A comprehensive literature search was made to obtain information pertinent to the study on reliability of discrete semiconductor devices. A computer search produced a bibliography, which was then reviewed for applicability. Data sources used in this computer search included the Defense Documentation Center (DDC), NASA Scientific and Aerospace Reports (STAR), and the National Technical Information Services (NTIS). In addition, Martin Marietta's Technical Information Center (TIC) was researched for recent applicable technical data.

Table 1. Summary of Operating Data by Group and Part Type

Group	Part Type	Part Hours
Transistors		
I	Si, NPN	45,480,000,000
	Si, PNP	19,375,000,000
	Ge, PNP	825,000,000
	Ge, NPN	1,635,000,000
II	FET	1,310,000,000
III	Unijunction	22,000,000
Diodes		
IV	Si, gen purpose	25,386,000,000
	Ge, gen purpose	1,232,000,000
V	Zener/avalanche	2,235,000,000
VI	Thyristors	253,650,000
VII	Varactor, step recovery, and tunnel	385,000,000

3.0 DATA ANALYSIS

3.1 Statistical Methods, Assumptions, and Ground Rules

Operational data on discrete semiconductors were collected, analyzed, and summarized by component type, use environment, and quality grade. The following sections describe the basic ground rules and assumptions used in this analysis and define the statistical tests used in combining the data. The method used for calculating failure rates at a given confidence level is included. Numerical examples are given for the statistical tests and the calculation of failure rates.

<u>Calculation of Failure Rates</u>

All failure rates are calculated at the upper single-sided 60 percent confidence level. Prior to calculating the confidence levels, it had to be determined whether the component data were time or failure truncated. Since no known instances of failure truncated information were reported, received, or documented, it was assumed that the data were time truncated. The upper 60 percent confidence level failure rate can be calculated by using the component part hours and the Chi square (χ^2) value at 2r + 2 degrees of freedom at the 40 percent level of significance point. If the data had been failure truncated, the value would be obtained at 2r degrees of freedom. The following general equation obtained from Reference 1 is used for calculating the failure rate:

$$\frac{\chi^2(\alpha,\ 2r + 2)}{2T} = \text{upper single-sided confidence level}$$

where

r = number of failures and determines the degree of freedom coordinate used in determining χ^2

$2r + 2$ = total number of degrees of freedom

α = acceptable risk of error (40 percent in this study)

$1-\alpha$ = confidence level (60 percent in this study)

T = total number of component part hours.

As an example, two failures during 20.722×10^6 part-hours of airborne operation were used in calculating the failure rate at the upper single-sided 60 percent confidence level. Reference 2 was used as the source for the χ^2 value. The results are as follows:

Reference 1. ARINC Research Corporation, "Reliability Engineering," p 173, Prentice-Hall Inc., Engelwood Cliffs, New Jersey, 1964.

Reference 2. Hald, A., "Statistical Tables and Formulas," Table V, pp 41-43, John Wiley and Sons, Inc., New York, 1952.

$$\text{Failure rate (60 percent confidence)} = \frac{\chi^2\ (0.40,\ 6)}{2T} = \frac{6.21}{41.444 \times 10^6}$$

Failure rate (60 percent confidence) = 0.150 failures/10^6 part-hours.

Since the statistical tables used are limited to χ^2 values up to 100 degrees of freedom, it was necessary to calculate an estimate of the χ^2 percentile points wherever more than 49 failures were observed in the data. In accordance with Reference 2, χ^2 confidence level values are approximated by:

$$\chi_p^2 \approx 1/2\ (Z_p + \sqrt{2f - 1})^2$$

where

χ_p^2 = approximated χ^2 value

f = total number of degrees of freedom

Z_p = 0.25335 and is the value of the standard normal variable at the 60 percent significance level.

Using actual data from silicon, NPN, transistors, which had 1060 failures in 11,271 x 10^6 part-hours of fixed ground operation, the failure rate for the upper single-sided 60 percent confidence level is calculated as follows:

$$\text{Failure rate (60 percent confidence)} = \frac{1/2(0.25335 + \sqrt{2(2122 - 1)})^2}{2(11{,}271 \times 10^6)}$$

Failure rate (60 percent confidence) = 0.095 failures/10^6 part-hours.

Test of Homogeneity of Data

As billions of part-hours of data are collected from many different sources, the analyst is faced with the task of determining how the data should be combined. Homogeneity of component/part-type populations must be maintained to prevent the introduction of bias and loss of precision in component failure rates. Therefore, all line items of failure rate data were carefully studied and evaluated, and then reordered and categorized on the basis of component type, component subgroup type, quality grade, and environmental application.

Before combining the data, a statistical test for homogeneity was required. The Dixon Criterion test was selected to statistically detect and identify those data entry failure rates that might significantly deviate from the family of failure rate entries under analysis. The ground rules and statistical assumptions used for Dixon Criterion testing are as follows:

1 Failure rate observations derived from each line entry come from a single normal population.

2 Population mean and standard deviation of the failure rate observations are unknown. The data sample, consisting of the failure rate line entries, is the only source of information.

3 The probability of risk (α) for rejecting an observation that truly belongs in the group is 10 percent. Line items significantly different at either end of a 90 percent two-sided confidence interval are culled from the sample before a final combined failure rate estimate is calculated. (See Calculation of Failure Rates (above) for a discussion of the method used for calculating confidence intervals.)

4 A minimum of three line entries of failure rate data is necessary in testing the homogeneity of the samples.

As an example, Table 2 contains five ordered line items of failure data received on silicon transistors and the formulas for identifying outliers at the upper and lower ends for a sample size of five items. The formula for testing at the high end for a sample size of four is also included.

Table 2. Combination of Failure Data Line Entries for Silicon Transistors

Failure Rate (Failures/10^6 Part-Hours)	Part-Hours ($\times 10^6$)	Failures
$X_1 = 0.00024$	8374.005	2
$X_2 = 0.00065$	1529.973	1
$X_3 = 0.00350$	288.586	1
$X_4 = 0.00480$	4538.441	22
$X_5 = 0.25000$	31.860	8

For a sample size of five and if the low end is suspect,

$$\text{reject } X_1 \text{ if } \frac{X_2 - X_1}{X_5 - X_1} \geq 0.642.$$

For a sample size of five and the high end is suspect,

$$\text{reject } X_5 \text{ if } \frac{X_5 - X_4}{X_5 - X_1} \geq 0.642.$$

For a sample size of four and the high end is suspect,

$$\text{reject } X_4 \text{ if } \frac{X_4 - X_3}{X_4 - X_1} \geq 0.765.$$

To test acceptability of sample X_1 at the low end, the applicable failure rates in failures per 10^6 part-hours are substituted into the corresponding formula and the result obtained is:

$$\frac{X_2 - X_1}{X_5 - X_1} = \frac{0.00065 - 0.00024}{0.25 - 0.00024} = 0.002.$$

This value is less than 0.642; therefore, for a sample size of five, the lowest ordered failure rate is within the acceptable boundary. To test acceptability of sample entry X_5 at the high end, again the applicable values are substituted into the corresponding formula for a sample size of five and the result obtained is:

$$\frac{X_5 - X_4}{X_5 - X_1} = \frac{0.250 - 0.0048}{0.250 - 0.00024} = 0.982.$$

This value is greater than 0.642. Therefore, the failure rate, 0.250, and its associated part-hours and failures must be rejected and would not be combined in the final failure rate estimate.

The test is rerun for a sample of four entries. Again, sample entry X_1 at the low end is found not be be rejected. At the high end, the result obtained is:

$$\frac{X_4 - X_3}{X_4 - X_1} = \frac{0.0048 - 0.0035}{0.0048 - 0.00024} = 0.285,$$

which is less than 0.765. This time all data are accepted. Thus, an iterative testing process using the Dixon Criterion is continued until both the low end and high end values are accepted.

The data and tables used for determining formulas and statistics to be applied for various sample sizes were obtained from Reference 3.

3.2 General Analysis Procedure

A general method for analyzing the collected data was utilized to compare base failure rates and the effects of different environments and quality grades. The method developed normalizes the effects of actual temperature and stress realized by the parts on which data were collected and compares the results to the existing base failure rates and modifying factors in MIL-HDBK-217B. Where significant differences occurred, revised model parameter values were derived. However, throughout the analysis, engineering logic was used in conjunction with analytical results in developing the model parameters.

Reference 3. Natrella, Mary G., "Experimental Statistics," pp 17-1 through 17-3, National Bureau of Standards Handbook 91, August 1963.

Additional analyses were performed to fill in gaps in the collected data with the primary purpose being to ensure consistency between a given model's quantitative factors that were changed as a result of the collected data and the remaining factors that could not be verified or changed because of lack of data.

Preparing Raw Data for Analysis

The general analysis method is illustrated by the procedure used to analyze the data collected on all discrete semiconductors. First, as shown in Figure 1, the data were summarized by environment and quality grade. The observed failure rate then calculated at the 60 percent one-sided upper confidence level. It was not practical to summarize the data to more detailed levels, such as temperature and stress, because the data then became so sparse in most categories that realistic failure rates could not be calculated. In most cases, temperature was found to remain in a reasonably narrow range (10 to 15°C) within a given use environment. For example, most fixed ground data were generated at an ambient temperature range of 30 to 40°C.

Second, the data were analyzed to determine predicted failure rates using MIL-HDBK-217B for each category upon which observed data exist. Temperature and stress information obtained from the data sources was used in determining these failure rates. If there were several temperatures/stresses involved for a given category, an average was used. However, this average was weighted heavily toward the source or sources representing the largest quantity of data. In a few cases the temperatures/stresses were not available from the data source and had to be estimated.

Base Failure Rate Analysis

Data were now ready to be analyzed for deviations from the existing MIL-HDBK-217B failure rate models. The procedure shown in Table 3 was used to determine differences in the observed versus predicted failure rates for specific environments and quality grades. Data in this table indicate that the basic failure rate in MIL-HDBK-217B for field effect transistors is too high since all environments have a low observed-to-predicted ratio. The weighted average was used to reduce the base failure rate, λ_b, in MIL-HDBK-217B for these devices. If the handbook base failure rate is reduced, the average of the predicted values is equal to the observed value.

Referring to Table 3, columns 1 and 2 are the cumulative number of failures and operating part-hours respectively from all data sources that have a common environmental application and quality factor. Columns 3 through 8 are the respective π which presently exist in MIL-HDBK-217B. Column 9 is a log number that provides traceability to the data base listing, which is included in Appendix D.

Column 10, the observed failure rate, is calculated from the data in columns 1 and 2, using the procedure described in the paragraph titled "Calculation of Failure Rates." Column 11 is the result of dividing Column 10 by the product of Columns 3 through 8 and produces a basic observed failure rate (λ_{bob}) that can be compared directly to the predicted failure rate. Column 12, the predicted failure rate, is selected from the existing tables of

MIL-HDBK-217B using the average stress ratio and operating temperature supplied by the data source. Finally, Column 13 is the ratio of observed failure rate to predicted failure rate, which measures the degree to which the study data base suggests a correction in MIL-HDBK-217B factors.

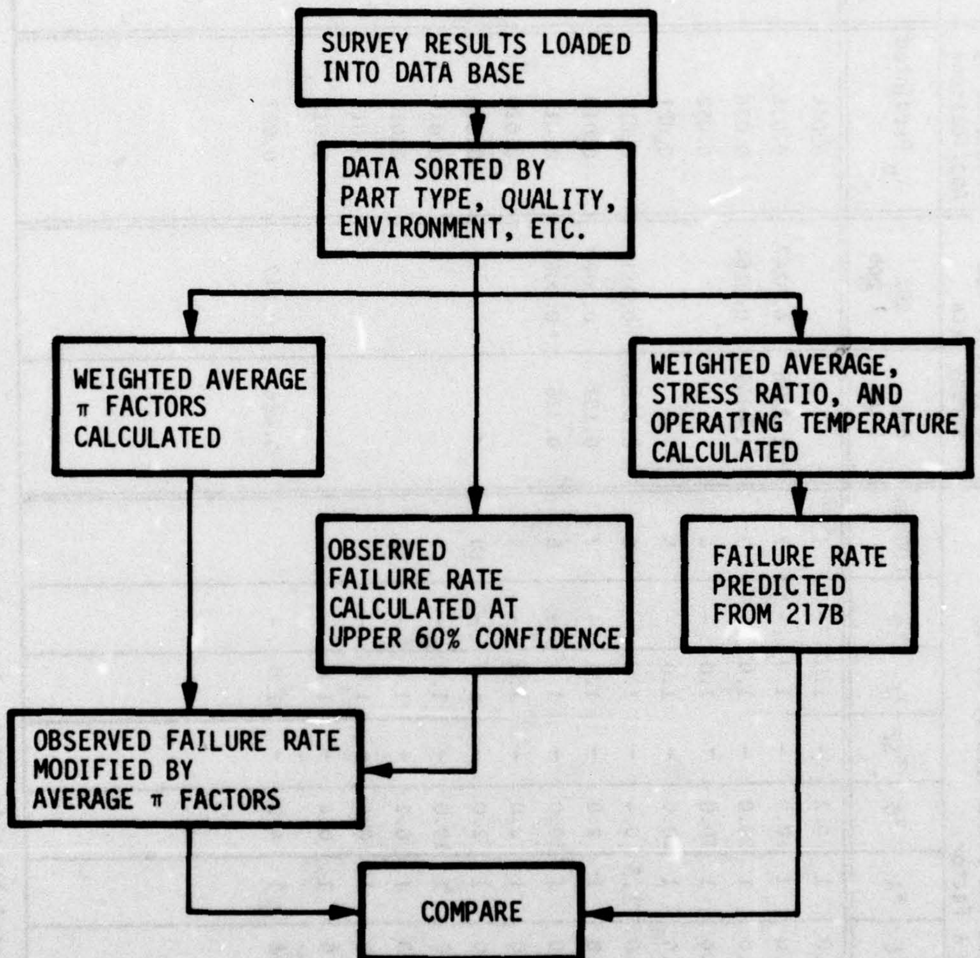

Figure 1. Sequence for Data Analysis

Table 3. Field Effect Transistors - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	2.264	1.0	1	0.2	=	1.0	-	1			0.044	
443	364.0	5.0	1	10.0	-	1.0	-	2	1.2338	0.0247	0.036	0.69
372	231.0	5.0	1	20.0	-	1.0	-	3	1.6349	0.0164	0.036	0.45
1*	0.021	25.0	1	10.0	-	1.0	-	4			0.052	
1*	1.019	25.0	1	20.0	-	1.0	-	5			0.021	
3	630.2	1.0	1.5	0.4	-	1.0	-	6	0.00663	0.011	0.015	0.73
5	45.978	25.0	1	2.0	-	1.0	-	7	0.137	0.0027	0.019	0.14
8	28.99	5.0	1	10.0	-	1.0	-	8	0.326	0.0065	0.017	0.38
0*	2.64	5.0	1	2.0	-	1.0	-	9			0.020	
0*	0.042	25.0	1	2.0	-	1.0	-	10			0.019	
0*	0.021	25.0	1	10.0	-	1.0	-	11			0.019	
0*	0.307	1.0	1	0.2	-	1.0	-	12			0.012	
0*	0.050	1.0	1	0.4	-	1.2	-	13			0.012	
0*	0.025	1.0	1	0.4	-	1.0	-	14			0.012	
2**	6.39	6.8	1	4.2	-	1.0	-		0.486	0.017	0.027	0.63
TOTALS												
833	1306.6											0.64

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.

π Factor Analysis

The correlation of failure rates of parts of various quality level and of differing environmental and other application circumstances was made by graphic comparison of the summarized and normalized data base. A one-dimensional graph such as the example shown in Figure 2 was used.

The data points are plotted according to the ratio of observed to predicted basic failure rate; the scale is shown on the left. The data points are arbitrarily spread horizontally across the page in order to allow room for a flag at each point to identify the associated environment and quality factor. Also, to provide a weighting factor, the number of part operating hours represented is shown. With relative ease one can compare and observe that the various factors are scattered throughout the distribution.

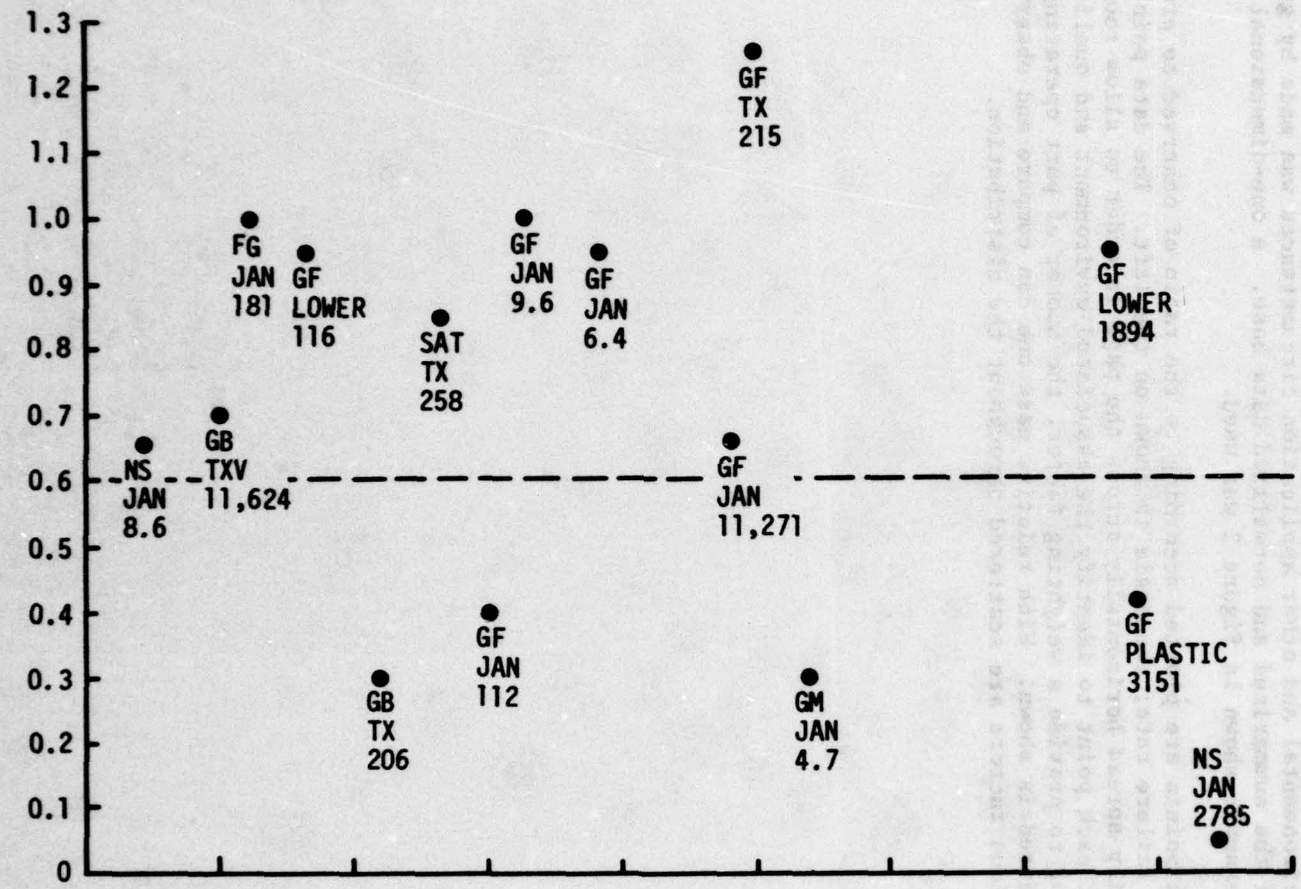

Figure 2. π Factor Analysis

4.0 ANALYSIS RESULTS

This section presents the results of analyzing the data collected during the program. These results are expressed in terms of recommended revisions to the existing data on MIL-HDBK-217B. The complete quantitative models and factors have been prepared for insertion in MIL-HDBK-217B. The primary revisions involve the environmental and quality factors. The airborne environment was expanded to four categories to separate the effects of supersonic aircraft such as fighters from other types of aircraft such as transports and heavy bombers. The recommended changes can be divided into two general categories: those that are clearly suggested by the data base of this study, and those that are suggested in literature and found to be compatible with the data base.

4.1 Environmental Factors

The vast majority of data were found in two principal environmental categories, ground fixed and naval sheltered. In the process of data analysis, much of the naval sheltered data were censored because of variances that did not fit in the distribution of the general data base. Since all of the non-conforming data were collected from a single source and no further examination was possible into the reporting methods of that contractor, it is assumed that some "sanitization" of the data had occurred and that it should be disregarded.

There existed an area of question as to interpretation of this data, however. Much of the naval sheltered data were collected from submarine applications, which may present a more benign environmental stress than defined for naval sheltered conditions. If, in fact, submarine environment approaches that of ground benign, and this data were reevaluated on that basis, much more of the data would have been accepted by the homogenity test. The effort allotted for this study did not permit a conclusive persuit of this matter.

Regardless, the naval sheltered data, which was retained in the data base, was supportive of the recommendation in Reference 4 that electronic failure rates are lower for shipboard environment than for aircraft environment.

The aircraft environment was expanded to four categories to separate supersonic aircraft from other types. It is generally accepted that equipment on supersonic aircraft is exposed to higher levels of shock, vibration, and acoustic noise, and to a more severe operating temperature range than equipment on other aircraft. Also the mission duration is usually much shorter for supersonic aircraft, thereby creating more cyclic problems. Therefore, significant differences in reliability are expected and have been observed. The quantitative relationships of the new factors were taken from the study reports

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Reference 4. Pearce, M.B. and Rise, G.D., "Technique for Developing Equipment Failure Rate K Factors," Boeing Aerospace Company, December 1973.

of References 4 and 5 and are summarized in Table 4. The subscripts F and T, as added to symbols A_I and A_U, designate application in fighter type aircraft and transport type aircraft respectively.

4.2 Quality Factors

After all data had been normalized and compared to a basic failure rate as predicted by existing MIL-HDBK-217B, the general pattern that emerged indicated an across-the-board variance in favor of the observed failure rates. This was attributed to the continuing maturation of the semiconductor manufacturing industry. With the advent of JANTX and JANTXV quality specifications and the growing market demand for these devices, more semiconductor production lines are being controlled to higher quality standards. Corrective action feedback from tests of the higher quality product tends to infuse quality improvement to all products in a given plant.

Revisions to MIL-HDBK-217B could be implemented either by reducing the base failure rate factor, A, or by reducing the quality π factors. The latter method was chosen and included in the changed section 2.2, which is included as attachment to this report.

4.3 Discrete Semiconductor Groupings

During the study a suggestion was received that semiconductors should be grouped according to MIL-STD-701. This suggestion has basis for consideration in that the semiconductor type groupings in MIL-STD-701 are generically related and therefore very likely have similar failure mechanisms, life characteristics, and temperature coefficients. A failure rate derived exclusively from field experience of devices of that family and a prediction model based upon that data would undoubtedly be more consistent.

However, the validity of this theory could not be established or rejected from the data. While over 200 billion hours of part operating data were collected, only a very few groupings from MIL-STD-701 included enough operation time to establish a statistically valid failure rate.

For example, the first group in MIL-STD-701, Table I, lists only two JEDEC registration numbers, 1N647 and 1N649. A JANTX quality device operated in ground benign environment at standard temperature (25°C) and 30 percent applied stress is predicted to have a mean time between failure of approximately 500 million hours. A test to evaluate the degree to which this reliability is achieved, would require accumulated part-hours equal to several times the expected MTBF, a number in excess of 1 billion hours. Likewise, this number of part operating hours would be required for each combination of environment, quality level, electrical stress, and temperature. Even with the present seven groups (excluding microwave transistors and diodes) we must make extensive use of extrapolation of data and engineering judgements to validate the existing models.

Reference 5. Kern, G.A., and Drnas, I.M., "Operational Influences on Reliability," p 5-4, Hughes Aircraft Company, RADC-TR-76-366, December 1976.

It is thus concluded, at least from the data base of this study, that any additional subdivision of groupings in MIL-HDBK-217 is not practical unless prediction models are established on some basis other than operating failure data.

Recommended changes are summarized in Tables 4 and 5.

Table 4. Environmental Factors

Old		New	
G_B	1	G_B	1
S_F	1	S_F	1
G_F	5	G_F	5
A_I	25	N_S	10
N_S	25	A_{IT}	12
G_M	25	A_{UT}	20
N_U	25	G_M	25
A_U	40	N_U	25
M_L	40	A_{IF}	25
		A_{UF}	40
		M_L	40

Table 5. Quality Factors

	Group I		Group II		Group III		Group IV		Group V	
Quality	Old	New	Old	New	Old	New	Old	New	Old	New
JANTXV	0.2	0.12	0.2	0.12	0.8	0.5	0.5	0.15	0.5	0.3
JANTX	0.4	0.24	0.4	0.24	1.6	1.0	1.0	0.3	1.0	0.6
JAN	2.0	1.2	2.0	1.2	8.0	5.0	5.0	1.5	5.0	3.0
Lower	10.0	6.0	10.0	6.0	40.0	25.0	25.0	7.5	25.0	15.0
Plastic	20.0	12.0	20.0	12.0	80.0	50.0	50.0	15.0	50.0	30.0

No changes were made in Groups VI and up.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A very substantial effort was made during this study program to gather all available data on semiconductor failure experience in field applications. Further, careful scrutiny was given the collected data to verify the accuracy and completeness of all variables that currently exist in MIL-HDBK-217B. It is believed that this study has been successful in bringing together some valid conclusions and in so doing has improved MIL-HDBK-217B.

Some consternation was felt by those involved with this project for the inordinate difficulty encountered in gathering a limited amount of information, at least when measured against the vast number of known semiconductor applications in military equipments. Part of this problem appears to be caused by the competitive nature of the aerospace industry and the real or imagined advantage that might be "given away" by divulging such information.

As a general conclusion from both the data analysis and from literature and survey comments, the mathematical models of section 2.2 in MIL-HDBK-217B are valid with only minor modifications required. These modifications include the changes to the environmental and quality π factors.

5.2 Recommendations

Detailed studies should be performed to determine the difference between submarine and shipboard sheltered environments. Data from these two environments were combined during this study because there was no statistical justification for separating them. This was a result of insufficient comparative data with which to perform a statistical test. Shipboard data are more difficult to obtain, because documentation of failures to the part level is not done as rigorously as for submarine systems.

Military data collection systems should be reevaluated so that more reliability oriented information can be collected. These systems presently are useful for logistics and replacement data studies, but are difficult and sometimes impossible to use as a source for reliability data. In defense of these data collection systems, note that one problem in collecting part-level data is the growing tendency to throw away failed modules rather than isolate and repair failed parts within them.

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15. "Semiconductor Vulnerability," AD 912136L

16. "Study of High Burnout Microwave Diodes," AD 883251

17. "Investigation of Effects of Nonrecurrent Forward Surge Currents on the Electrical Parameters of the 2N1913SCR," AD 873142

18. "Investigation of Current Mode Second Breakdown," AD 787519

19. "Technique for Developing Equipment Failure Rate K Factors," AD 916002L

APPENDIX A

DATA SOURCES

DATA SOURCES

Aerojet Corporation
Azusa, California

Autonetics
Anaheim, California

Electronic Communications, Inc.
St. Petersburg, Florida

Ford Aerospace & Communications
Palo Alto, California

General Dynamics
Pomona, California

General Electric Corporation
Syracuse, New York

GIDEP
Corona, California

Harris Corporation
Melbourne, Florida

Hewlett Packard
Palo Alto, California

Litton Industries
Van Nuys, California

Magnavox Corporation
Fort Wayne, Indiana

Martin Marietta Corporation
Orlando, Florida

Raytheon Corporation
Wayland, Massachusetts

RCA Consumer Products
Indianapolis, Indiana

Reliability Analysis Center
Rome, New York

Sperry Univac
St. Paul, Minnesota

Sperry Systems Management
Great Neck, New York

APPENDIX B

INTERMEDIATE DATA SUMMARY - TRANSISTORS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
490	FET	GB	JANTXV	057B	2.264	0	37		.7	FET
	1. TOTAL				2.264 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
226	FET	GF	LOWER	053	227	207	55		.5	N CHAN
228	FET	GF	LOWER	053	0	26	55		.5	N CHAN
225	FET	GF	LOWER	053	10	0	55		.5	P CHAN
229	FET	GF	LOWER	053	109	195	55		.5	N CHAN
223	FET	GF	LOWER	053	10	7	55		.5	P CHAN
	2. TOTAL				364 MILLION HOURS	443 FAILURES			RATE IS	1.21703 FAIL/10**6HRS
227	FET	GF	PLASTIC	053	160	320	55		.5	N CHAN
224	FET	GF	PLASTIC	053	63	44	55		.5	P CHAN
	3. TOTAL				231 MILLION HOURS	372 FAILURES			RATE IS	1.61039 FAIL/10**6HRS
409	FET	GM	LOWER	054	.021	1	30		.8	FET
	4. TOTAL				.021 MILLION HOURS	1 FAILURES			RATE IS	47.619 FAIL/10**6HRS
501	FET	NS	LOWER	032AG	1.019	1	40		.3	
	5. TOTAL				1.019 MILLION HOURS	1 FAILURES			RATE IS	.981354 FAIL/10**6HRS
517	FET	SAT	JANTX	058C	.543	0	25		.05	
519	FET	SAT	JANTX	058D	.402	0	25		.05	
232	FET	SAT	JANTX	052	629.3	3	25		.2	
	6. TOTAL				630.245 MILLION HOURS	3 FAILURES			RATE IS	.476005E-2 FAIL/10**6HRS
221	FET	SUB	JAN	014	4	1	40	<1W	.25	
222	FET	SUB	JAN	014	41.978	4	45	>1W	.25	
	7. TOTAL				45.978 MILLION HOURS	5 FAILURES			RATE IS	.108748 FAIL/10**6HRS
713	FET-N	GF	LOWER	063	16.81	6	30		.1	
714	FET-N	GF	LOWER	063	12.18	2	30		.4	
	8. TOTAL				28.99 MILLION HOURS	8 FAILURES			RATE IS	.275957 FAIL/10**6HRS
294	JFET	GF	JAN	055A	.961	0	35		.3	DUAL
293	JFET	GF	JAN	055A	.067	0	35		.3	DUAL
291	JFET	GF	JAN	055A	.434	0	35		.3	
292	JFET	GF	JAN	055A	.217	0	35		.3	
295	JFET	GF	JAN	055A	.961	0	35		.3	
	9. TOTAL				2.64 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
703	JFET.NCHAN	GM	JAN	066	.0416	0	30		.3	
	10. TOTAL	.0416 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
704	JFET.NCHAN	GM	LOWER	066	.0208	0	30		.3	
	11. TOTAL	.0208 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
659	JFET.NCHAN	SAT	JANTX	058E	.02505	0	25		.035	
601	JFET.NCHAN	SAT	JANTX	058E	.07516	0	25		.017	
570	JFET.NCHAN	SAT	JANTX	058E	.0501	0	25		.025	
585	JFET.NCHAN	SAT	JANTX	058E	.01253	0	25		.1	
664	JFET.NCHAN	SAT	JANTX	058E	.01879	0	25		.073	
590	JFET.NCHAN	SAT	JANTX	058E	.012526	0	25		.1	
637	JFET.NCHAN	SAT	JANTX	058E	.02505	0	25		.05	
629	JFET.NCHAN	SAT	JANTX	058E	.06263	0	25		.003	
682	JFET.NCHAN	SAT	JANTX	058E	.02505	0	25		.01	
	12. TOTAL	.306086 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
577	JFET.NCHAN.DUAL	SAT	JANTX	058E	.0501	0	25		.1	
	13. TOTAL	.0501 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
583	JFET.PCHAN	SAT	JANTX	058E	.02505	0	25		.1	
	14. TOTAL	.02505 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
499	NPN.GER	NS	JAN	032AG	.059	0	40		.5	
	15. TOTAL	.059 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
482	NPN.GER.SW	GF	JAN	055B	4.051	6	30	1W	.75	
	16. TOTAL	4.051 MILLION HOURS				6 FAILURES			RATE IS	1.48112 FAIL/10**6HRS
480	NPN.GER.SW	SUB	JAN	051B	1499.577	6	35	.15W	.2	
481	NPN.GER.SW	SUB	JAN	051B	132.644	0	35	.15W	.2	
	17. TOTAL	1632.22 MILLION HOURS				6 FAILURES			RATE IS	.367597E-2 FAIL/10**6HRS
497	NPN.SI	NS	JAN	032AG	8.594	0	40		.3	
	18. TOTAL	8.594 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
731	NPN.SI.LIN	AI	JANTX	049	.498	0	45	4W,200V	.5	
736	NPN.SI.LIN	AI	JANTX	049	.896	0	45	1W	.5	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10↑6	FAIL	TEMP	RATING	STRESS	COMMENTS
245	NPN.SI.LIN	AI	JANTX	045	.004	0	55	55W. 400V	.264..363V	
261	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	0..11V	
246	NPN.SI.LIN	AI	JANTX	045	.008	0	55	67W.400V	.094. .55V	
253	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	0..11V	
66	NPN.SI.LIN	AI	JANTX	045	.008	0	55	2.94 W. 50 V	.002. .016 V	
73	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	.03. .016 V	
82	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	0.0. .1 V	
60	NPN.SI.LIN	AI	JANTX	045	.004	0	55	4.1 W. 40 V	.005. .195 V	
57	NPN.SI.LIN	AI	JANTX	045	.004	0	55	3.98 W. 40 V	.007. .195 V	
251	NPN.SI.LIN	AI	JANTX	045	.004	0	55	4.1W.40V	.011. .145V	
97	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	.002. .02 V	
140	NPN.SI.LIN	AI	JANTX	045	.008	0	55	115.0 W. 80 V	.052. .55 V	
258	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	.002..016V	
58	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93 W. 50 V	0.0. .11 V	
67	NPN.SI.LIN	AI	JANTX	045	.004	0	55	4.1 W. 40 V	.011. .145 V	
87	NPN.SI.LIN	AI	JANTX	045	.004	0	55	.5 W. 50 V	.01. .1 V	
81	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	.002. .232 V	
83	NPN.SI.LIN	AI	JANTX	045	.004	0	55	120 W. 400V	.01. .363 V	
69	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93 W. 50 V	0.0. .11 V	
145	NPN.SI.LIN	AI	JANTX	045	.004	0	55	107 W. 400 V	.011. .363 V	
76	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	0.0. .100 V	
263	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	.002..016V	
70	NPN.SI.LIN	AI	JANTX	045	.008	0	55	3.27 W. 40 V	.106. .195 V	
247	NPN.SI.LIN	AI	JANTX	045	.004	0	55	80W.150V	.049. .003V	
255	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	.004..076V	
84	NPN.SI.LIN	AI	JANTX	045	.004	0	55	120 W. 400 V	.121. .363 V	
252	NPN.SI.LIN	AI	JANTX	045	.004	0	55	4.1W.40V	.005. .195V	
150	NPN.SI.LIN	AI	JANTX	045	.004	0	55	115.0 W. 80 V	.031. .045V	
250	NPN.SI.LIN	AI	JANTX	045	.004	0	55	50V	.1V	
75	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	.002..11 V	
249	NPN.SI.LIN	AI	JANTX	045	.004	0	55	5V	1V	
146	NPN.SI.LIN	AI	JANTX	045	.004	0	55	105 W. 80 V	.136. .363V	
147	NPN.SI.LIN	AI	JANTX	045	.004	0	55	120 W. 400 V	.122. .04 V	
149	NPN.SI.LIN	AI	JANTX	045	.004	0	55	115.0 W. 80 V	.025. .036V	
260	NPN.SI.LIN	AI	JANTX	045	.004	0	55	3.98W.40V	.007..195V	
72	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	0.0. .3 V	
71	NPN.SI.LIN	AI	JANTX	045	.008	0	55	2.9 W. 50 V	0.0. .11 V	
244	NPN.SI.LIN	AI	JANTX	045	.004	0	55	85W.400V	.014..363V	
264	NPN.SI.LIN	AI	JANTX	045	.004	0	55	3.98W.40V	.012..145V	
262	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	0..30V	
85	NPN.SI.LIN	AI	JANTX	045	.008	1	55	107 W. 400 V	.06. .55V	
96	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.9 W. 50 V	0.0. .3 V	
65	NPN.SI.LIN	AI	JANTX	045	.008	0	55	2.94 W. 50 V	0.0. .3 V	
254	NPN.SI.LIN	AI	JANTX	045	.004	0	55	2.93W.50V	0..100V	
74	NPN.SI.LIN	AI	JANTX	045	.004	0	55	3.2 W. 40 V	.014. .145 V	
259	NPN.SI.LIN	AI	JANTX	045	.004	0	55	3.98W.40V	.012..145V	

19. TOTAL 1.606 MILLION HOURS 1 FAILURES RATE IS .622666 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
483	NPN.SI.LIN	AU	JANTX	056	.001332	0		.2W		
386	NPN.SI.LIN	AU	JANTX	056	.000140	0	30	.8W		
390	NPN.SI.LIN	AU	JANTX	056	.002111	0	30	.36W		
391	NPN.SI.LIN	AU	JANTX	056	.000088	0	30	.2W		
392	NPN.SI.LIN	AU	JANTX	056	.000187	0	30	.3W		
395	NPN.SI.LIN	AU	JANTX	056	.000296	0	30	5W		
394	NPN.SI.LIN	AU	JANTX	056	.000266	0	30	.5W		
	20. TOTAL	.005228 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
200	NPN.SI.LIN	GB	JANTXV	051A	4459.65	1	10	360MW.60V	5	
749	NPN.SI.LIN	GB	JANTXV	051A	429.046	0	10	200MW.15V	.5	
743	NPN.SI.LIN	GB	JANTXV	051A	5946.20	1	10	1.0W.45V	.5	
131	NPN.SI.LIN	GB	JANTXV	051A	788.05	2	10	1.2W.80V	.5	
	21. TOTAL	11623.7 MILLION HOURS				4 FAILURES			RATE IS	.344123E-3 FAIL/10**6HRS
303	NPN.SI.LIN	GF	JAN	055B	16.002	2	30	4W	.25-.5	
305	NPN.SI.LIN	GF	JAN	055B	.532	0	30	30W	.25-.5	
302	NPN.SI.LIN	GF	JAN	055B	.075	5	30	2W	.25-.5	
306	NPN.SI.LIN	GF	JAN	055B	1.887	0	30	50W	.25-.5	
359	NPN.SI.LIN	GF	JAN	054	.056	0	30	1W	.8	
301	NPN.SI.LIN	GF	JAN	055B	5.496	1	30	1W	.25-.5	
299	NPN.SI.LIN	GF	JAN	055B	1.795	0	30	1W	.25-.5	
316	NPN.SI.LIN	GF	JAN	055A	3.606	0	35	17.5W	.25-.5	
125	NPN.SI.LIN	GF	JAN	049A	3.017704	0	35		.5	PWR
339	NPN.SI.LIN	GF	JAN	055A	7.339	1	35	2.5W	.25-.5	
120	NPN.SI.LIN	GF	JAN	049A	1.91982	1	35		.5	
314	NPN.SI.LIN	GF	JAN	055A	.064	0	35	10W	.25-.5	
337	NPN.SI.LIN	GF	JAN	055A	23.086	0	35	<1W	.25-.5	
315	NPN.SI.LIN	GF	JAN	055A	1.104	0	35	11.6W	.25-.5	
324	NPN.SI.LIN	GF	JAN	055B	101.05	9	35	1W	.25-.5	
319	NPN.SI.LIN	GF	JAN	055A	.08	0	35	30W	.25-.5	
313	NPN.SI.LIN	GF	JAN	055A	.732	0	35	7W	.25-.5	
340	NPN.SI.LIN	GF	JAN	055A	1.054	!	35	5W	.25-.5	
126	NPN.SI.LIN	GF	JAN	049A	9.205954	16	35	4W	.5	
	22. TOTAL	180.661 MILLION HOURS				36 FAILURES			RATE IS	.199268 FAIL/10**6HRS
376	NPN.SI.LIN	GF	JANTX	051C	.127	0	25	150W	.3	
372	NPN.SI.LIN	GF	JANTX	051C	.007	0	25	.8W	.3	
374	NPN.SI.LIN	GF	JANTX	051C	.15	0	25	.8W	.3	
111	NPN.SI.LIN	GF	JANTX	049	3.584	0	45	1 W	.5	
106	NPN.SI.LIN	GF	JANTX	049	1.992	0	45	4 W. 200 V	.5	
	23. TOTAL	5.86 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
370	NPN.SI.LIN	GF	LOWER	051C	.214	0	25	150W	.3	
378	NPN.SI.LIN	GF	LOWER	051C	.071	0	25	20W	.3	
494	NPN.SI.LIN	GF	LOWER	053	116	120	55		.5	DUAL
	24. TOTAL	116.285 MILLION HOURS				120 FAILURES			RATE IS	1.03195 FAIL/10**6HRS
702	NPN.SI.LIN	GM	JAN	066	.0033	0	30	800MW.100V		
383	NPN.SI.LIN	GM	JAN	054	.06	0	30	115W	.8	
356	NPN.SI.LIN	GM	JAN	054	.116	0	30	.3W	.8	
357	NPN.SI.LIN	GM	JAN	054	.06	0	30	.8W	.8	
358	NPN.SI.LIN	GM	JAN	054	.042	0	30	1W	.8	
	25. TOTAL	.3613 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
700	NPN.SI.LIN	GM	JANTX	066	.5831	0	30	150W.80V	.3	
606	NPN.SI.LIN	GM	JANTX	066	.6664	0	30	200MW.15V	.3	
	26. TOTAL	1.2495 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
373	NPN.SI.LIN	NS	JANTX	051C	.062	0	35	.8W	.3	
375	NPN.SI.LIN	NS	JANTX	051C	.052	0	35	150W	.3	
371	NPN.SI.LIN	NS	JANTX	051C	.003	0	35	.8W	.3	
	27. TOTAL	.117 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
369	NPN.SI.LIN	NS	LOWER	051C	.098	0	35	150W	.3	
377	NPN.SI.LIN	NS	LOWER	051C	.033	0	35	20W	.3	
	28. TOTAL	.131 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
661	NPN.SI.LIN	SAT	JANTX	050E	.03477	0	25	250MW.60V	.09	
653	NPN.SI.LIN	SAT	JANTX	050E	.09561	0	25	200MW.15V	.035	
642	NPN.SI.LIN	SAT	JANTX	050E	.01730	0	25	360MW.60V	.08	
552	NPN.SI.LIN	SAT	JANTX	050E	.02608	0	25	1W.80V	.053	
525	NPN.SI.LIN	SAT	JANTX	050A	40.864	0	25	500MW.50V	.1	
532	NPN.SI.LIN	SAT	JANTX	050A	14.252	0	25	250MW.60V	.1	
526	NPN.SI.LIN	SAT	JANTX	050A	36.640	0	25	800MW.100V	.1	
670	NPN.SI.LIN	SAT	JANTX	050E	.37010	0	25	1.0W.45V	.012	
500	NPN.SI.LIN	SAT	JANTX	050E	.06954	0	25	1W.150V	.1	
599	NPN.SI.LIN	SAT	JANTX	050E	.55629	0	25	200MW.15V	.092	
617	NPN.SI.LIN	SAT	JANTX	050E	.14776	0	25	200MW.15V	.083	
603	NPN.SI.LIN	SAT	JANTX	050E	.01730	0	25	1.8W.45V	.1	
524	NPN.SI.LIN	SAT	JANTX	050A	34.612	0	25	200MW.15V	.1	
600	NPN.SI.LIN	SAT	JANTX	050E	.03477	0	25	200MW.15V	.097	
620	NPN.SI.LIN	SAT	JANTX	050E	.03477	0	25	3.5W.35V	.057	
615	NPN.SI.LIN	SAT	JANTX	050E	.02122	0	25	115W.60V	.1	
691	NPN.SI.LIN	SAT	JANTX	050E	.00869	0	25	1W.150V	.1	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10**6	FAIL	TEMP	RATING	STRESS	COMMENTS
606	NPN.SI.LIN	SAT	JANTX	050E	.00069	0	25	300MW.15V	.022	
560	NPN.SI.LIN	SAT	JANTX	050E	.20061	0	25	360MW.60V	.1	
644	NPN.SI.LIN	SAT	JANTX	050E	.01730	0	25	500MW.50V	.23	
533	NPN.SI.LIN	SAT	JANTX	050A	0.144	0	25	250MW.60V	.1	
616	NPN.SI.LIN	SAT	JANTX	050E	.07023	0	25	200MW.15V	.106	
531	NPN.SI.LIN	SAT	JANTX	050A	4.072	0	25	500MW.80V	.1	
579	NPN.SI.LIN	SAT	JANTX	050E	.03477	0	25	360MW.60V	.1	
601	NPN.SI.LIN	SAT	JANTX	050E	.02600	0	25	600MW.20V	.104	
565	NPN.SI.LIN	SAT	JANTX	050E	.13030	0	25	200MW.15V	.077	
529	NPN.SI.LIN	SAT	JANTX	050A	4.072	0	25	600MW.20V	.1	
634	NPN.SI.LIN	SAT	JANTX	050E	.04346	0	25	200MW.15V	.056	
605	NPN.SI.LIN	SAT	JANTX	050E	.00069	0	25	1W.150V	.1	
636	NPN.SI.LIN	SAT	JANTX	050E	.01730	0	25	300MW.15V	.05	
632	NPN.SI.LIN	SAT	JANTX	050E	.04243	0	25	2W.60V	.162	
643	NPN.SI.LIN	SAT	JANTX	050E	.06954	0	25	250MW.60V	.06	
676	NPN.SI.LIN	SAT	JANTX	050E	.02600	0	25	1W.80V	0	
690	NPN.SI.LIN	SAT	JANTX	050E	.01061	0	25	20W.80V	.4	
520	NPN.SI.LIN	SAT	JANTX	050A	104.054	0	25	360MW.60V	.1	
564	NPN.SI.LIN	SAT	JANTX	050E	.02600	0	25	200MW.15V	.044	
	29. TOTAL	257.709	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
332	NPN.SI.LIN	SUB	JAN	051B	2.369	0	35	30W	.3	
329	NPN.SI.LIN	SUB	JAN	051B	2.369	0	35	150W	.3	
364	NPN.SI.LIN	SUB	JAN	051B	60.701	0	35	1W	.3	
353	NPN.SI.LIN	SUB	JAN	051B	170.560	3	35	50W	.3	
342	NPN.SI.LIN	SUB	JAN	051B	923.910	2	35	.8W	.3	
330	NPN.SI.LIN	SUB	JAN	051B	204.20	0	35	.5W	.3	
341	NPN.SI.LIN	SUB	JAN	051B	912.065	3	35	.5W	.3	
345	NPN.SI.LIN	SUB	JAN	051B	9.476	0	35	85W	.3	
351	NPN.SI.LIN	SUB	JAN	051B	56.056	0	35	1.0W	.3	
365	NPN.SI.LIN	SUB	JAN	051B	2.369	0	35	4W	.3	
331	NPN.SI.LIN	SUB	JAN	051B	397.992	0	35	.8W	.3	
367	NPN.SI.LIN	SUB	JAN	051B	431.150	0	35	4W	.3	
366	NPN.SI.LIN	SUB	JAN	051B	20.420	0	35	4W	.3	
	30. TOTAL	3290.54	MILLION HOURS			0	FAILURES		RATE IS	.243121E-2 FAIL/10**6HRS
130	NPN.SI.LIN.DUAL	GF	JAN	049A	111.6551	1	35		.5	STRESS ASSUMED
	31. TOTAL	111.655	MILLION HOURS			1	FAILURES		RATE IS	.895615E-2 FAIL/10**6HRS
540	NPN.SI.LIN.DUAL	SAT	JANTX	050E	.0522	0	25	300MW.60V	.001	PWR IS GIVEN PER SIDE
574	NPN.SI.LIN.DUAL	SAT	JANTX	050E	.008692	0	25	250MW.60V	.018	PWR GIVEN PER SIDE
	32. TOTAL	.060892	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
122	NPN.SI.LIN.DUAL.MATCHED	GF	JAN	049A	3.017704	0	35		.5	
	33. TOTAL	3.0177	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
115	NPN.SI.LIN.PWR	GF	JAN	049A	7.67920	2	35	4W	.5	
114	NPN.SI.LIN.PWR	GF	JAN	049A	.95991	0	35	50W	.5	
113	NPN.SI.LIN.PWR	GF	JAN	049A	.95991	0	35		.5	
	34. TOTAL	9.5991	MILLION HOURS			2	FAILURES		RATE IS	.208353 FAIL/10**6HRS
200	NPN.SI.PWR	GF	JAN	055A	6.344	0	35		.25-.5	
202	NPN.SI.PWR	GF	JAN	055A	.096	0	35		.25-.5	
	35. TOTAL	6.44	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
290	NPN.SI.PWR	GM	LOWER	054	.042	0	30		.8	
289	NPN.SI.PWR	GM	LOWER	054	.083	0	30		.8	
288	NPN.SI.PWR	GM	LOWER	054	.028	0	30		.8	
	36. TOTAL	.153	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
538	NPN.SI.PWR	SAT	JANTX	058A	.605	0	25	11.6W.40V	.1	
536	NPN.SI.PWR	SAT	JANTX	058A	1.370	0	25	40W.100V	.1	
537	NPN.SI.PWR	SAT	JANTX	058A	5.823	0	25	53W.80V	.1	
	37. TOTAL	7.878	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
734	NPN.SI.SW	AI	JANTX	049	.944	0	45	.8W	.5	
733	NPN.SI.SW	AI	JANTX	049	18.994	1	45	.36W	.5	
732	NPN.SI.SW	AI	JANTX	049	17.402	2	45	.5W	.5	
737	NPN.SI.SW	AI	JANTX	049	.994	0	45	.36W	.5	
735	NPN.SI.SW	AI	JANTX	049	14.610	3	45	.36W	.5	
730	NPN.SI.SW	AI	JANTX	049	.298	0	45	100W. 400V	.5	
79	NPN.SI.SW	AI	JANTX	045	.004	0	55	1.37 W.40 V	0.0. .120 V	
240	NPN.SI.SW	AI	JANTX	045	.004	0	55	114W.150V	.077. .003V	
104	NPN.SI.SW	AI	JANTX	045	.004	0	55	1.3 W.50 V	0.0. .1 V	
77	NPN.SI.SW	AI	JANTX	045	.004	0	55	1.37 W. 60 V	0.0. .012 V	
80	NPN.SI.SW	AI	JANTX	045	.004	0	55	.5 W. 50 V	0.0. .1 V	
80	NPN.SI.SW	AI	JANTX	045	.004	0	55	1.37 W. 40 V	0.0. .150 V	
78	NPN.SI.SW	AI	JANTX	045	.004	0	55	1.37 W. 40 V	.002. .145 V	
	38. TOTAL	53.278	MILLION HOURS			6	FAILURES		RATE IS	.112617 FAIL/10**6HRS
396	NPN.SI.SW	AU	JANTX	056	.000592	0	30	.36W	.5	
393	NPN.SI.SW	AU	JANTX	056	.000187	0	30	.8W	.3	
387	NPN.SI.SW	AU	JANTX	056	.000140	0	30	.8W	.3	
389	NPN.SI.SW	AU	JANTX	056	.001924	0	30	.36W	.3	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10**6	FAIL	TEMP	RATING	STRESS	COMMENTS
388	NPN.SI.SW	AU	JANTX	056	.014159	0	30	.5W	.3	
	39.TOTAL	.01701	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
750	NPN.SI.SW	GB	JANTXV	051A	1074.61	0	10	75W.90V	.5	
747	NPN.SI.SW	GB	JANTXV	051A	662.679	0	10	75W.90V	.5	
746	NPN.SI.SW	GB	JANTXV	051A	107.461	0	10	125W.90V	.5	
745	NPN.SI.SW	GB	JANTXV	051A	4226.82	0	10	360MW.20V	.5	
	40. TOTAL	6071.57	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
134	NPN.SI.SW	GF	JAN	044A	2759	555	25	1 W	.3	
135	NPN.SI.SW	GF	JAN	044A	2759.	351	25	22 W	.3	
325	NPN.SI.SW	GF	JAN	055B	058.145	47	30	1W	.25-.5	
300	NPN.SI.SW	GF	JAN	055B	.046	0	30	1W	.25-.5	
308	NPN.SI.SW	GF	JAN	055B	4.124	2	30	150W	.25-.5	
326	NPN.SI.SW	GF	JAN	055B	.46	0	30	.8W	.25-.5	
309	NPN.SI.SW	GF	JAN	055B	.046	0	30	170W	.25-.5	
304	NPN.SI.SW	GF	JAN	055B	31.77	0	30	25W	.25-.5	
307	NPN.SI.SW	GF	JAN	055B	3.765	2	30	75W	.25-.5	
117	NPN.SI.SW	GF	JAN	049A	14.39065	0	35		.5	
323	NPN.SI.SW	GF	JAN	055A	.24	0	35	150W	.25-.5	
123	NPN.SI.SW	GF	JAN	049A	395.1339	4	35		.5	
119	NPN.SI.SW	GF	JAN	049A	.95991	0	35		.5	
121	NPN.SI.SW	GF	JAN	049A	1.91982	0	35		.5	
110	NPN.SI.SW	GF	JAN	049A	0.63919	0	35	.8W	.5	
137	NPN.SI.SW	GF	JAN	049A	020.1051	14	35	.5W	.5	STRESS ASSUMED
322	NPN.SI.SW	GF	JAN	055A	517.54	16	35	100W	.25-.5	
317	NPN.SI.SW	GF	JAN	055A	.961	0	35	10W	.25-.5	
124	NPN.SI.SW	GF	JAN	049A	.1392	1	35		.5	
320	NPN.SI.SW	GF	JAN	055A	3.736	0	35	.5W	.25-.5	
330	NPN.SI.SW	GF	JAN	055A	1206.406	7	35	<1W	.25-.5	
142	NPN.SI.SW	GF	JAN	049A	200.4324	10	35	.36W	.5	STRESS ASSUMED
140	NPN.SI.SW	GF	JAN	049A	146.7453	2	35		.5	STRESS ASSUMED
310	NPN.SI.SW	GF	JAN	055A	.003	0	35	25W	.25-.5	
141	NPN.SI.SW	GF	JAN	049A	454.0207	24	35	.36W	.5	STRESS ASSUMED
116	NPN.SI.SW	GF	JAN	049A	.95991	0	35		.5	
143	NPN.SI.SW	GF	JAN	049A	211.2393	9	35		.5	STRESS ASSUMED
139	NPN.SI.SW	GF	JAN	049A	509.2165	9	35	.36W	.5	STRESS ASSUMED
136	NPN.SI.SW	GF	JAN	049A	193.1331	7	35		.5	STRESS ASSUMED
321	NPN.SI.SW	GF	JAN	055A	.067	0	35	75W	.25-.5	
	41.TOTAL	11271.3	MILLION HOURS			1060	FAILURES		RATE IS	.940441E-1 FAIL/10**6HRS
274	NPN.SI.SW	GF	JANTX	051C	.374	0	25	2W	.2	
270	NPN.SI.SW	GF	JANTX	051C	.006	0	25	80W	.2	
276	NPN.SI.SW	GF	JANTX	051C	.191	0	25	80W	.2	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
268	NPN.SI.SW	GF	JANTX	051C	.862	0	25	.5W	.2	
270	NPN.SI.SW	GF	JANTX	051C	.241	0	25	.5W	.2	
266	NPN.SI.SW	GF	JANTX	051C	.06	0	25	.8W	.2	
272	NPN.SI.SW	GF	JANTX	051C	.048	0	25	1W	.2	
108	NPN.SI.SW	GF	JANTX	049	75.976	0	45	.36 W	.5	
109	NPN.SI.SW	GF	JANTX	049	3.776	0	45	.8 W	.5	
107	NPN.SI.SW	GF	JANTX	049	69.608	1	45	.5 W	.5	
112	NPN.SI.SW	GF	JANTX	049	3.976	0	45	.36 W	.5	
110	NPN.SI.SW	GF	JANTX	049	58.472	2	45	.36 W	.5	
105	NPN.SI.SW	GF	JANTX	049	1.192	0	45	100W, 400V	.5	
	42. TOTAL	214.862 MILLION HOURS				3 FAILURES			RATE IS	.139625E-1 FAIL/10**6HRS
729	NPN.SI.SW	GF	JANTXV	068	3.56390	0	30	.5W	<.3	
	43. TOTAL	3.5639 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
360	NPN.SI.SW	GM	JAN	054	.396	0	30	1W	.8	
355	NPN.SI.SW	GM	JAN	054	.035	0	30	.3W	.8	
379	NPN.SI.SW	GM	JAN	054	.167	0	30	25W	.8	
382	NPN.SI.SW	GM	JAN	054	.486	0	30	.36W	.8	
380	NPN.SI.SW	GM	JAN	054	.472	0	30	.8W	.8	
381	NPN.SI.SW	GM	JAN	054	3.117	0	30	.5W	.8	
	44. TOTAL	4.673 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
695	NPN.SI.SW	GM	JANTX	066	0.122	0	30	500MW.40V	.5	
694	NPN.SI.SW	GM	JANTX	066	.0416	0	30	800MW.50V	.5	
693	NPN.SI.SW	GM	JANTX	066	.0416	0	30	25W.60V	.5	
	45. TOTAL	0.2052 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
310	NPN.SI.SW	GM	LOWER	054	3.255	0	30	.8W	.8	
706	NPN.SI.SW	GM	LOWER	066	.1562	0	30	310MW.40V		
311	NPN.SI.SW	GM	LOWER	054	2.341	0	30	.8W	.8	
304	NPN.SI.SW	GM	LOWER	054	.014	0	30	.36W	.8	
312	NPN.SI.SW	GM	LOWER	054	2.36	0	30	.8W	.8	
	46. TOTAL	8.1262 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HPS
275	NPN.SI.SW	NS	JANTX	051C	.079	0	35	80W	.2	
271	NPN.SI.SW	NS	JANTX	051C	.02	0	35	1W	.2	
267	NPN.SI.SW	NS	JANTX	051C	.35	0	35	.5W	.2	
265	NPN.SI.SW	NS	JANTX	051C	.026	0	35	.8W	.2	
277	NPN.SI.SW	NS	JANTX	051C	.039	0	35	80W	.2	
273	NPN.SI.SW	NS	JANTX	051C	.151	0	35	2W	.2	
269	NPN.SI.SW	NS	JANTX	051C	.105	0	35	.5W	.2	
	47. TOTAL	.77 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SPCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
555	NPN.SI.SW	SAT	JANTX	058E	.02608	0	25	300MW.30V	.1	
553	NPN.SI.SW	SAT	JANTX	058E	.1304	0	25	300MW.75V	.1	
690	NPN.SI.SW	SAT	JANTX	058E	.00435	0	25	300MW.30V	.1	
692	NPN.SI.SW	SAT	JANTX	058E	.005304	0	25	25W.100V	.2	
551	NPN.SI.SW	SAT	JANTX	058E	.3738	0	25	500MW.40V	.072	
575	NPN.SI.SW	SAT	JANTX	058E	.61713	0	25	360MW.30V	.095	
527	NPN.SI.SW	SAT	JANTX	058A	22.396	0	25	360MW.40V	.1	
589	NPN.SI.SW	SAT	JANTX	058E	.000692	0	25	300MW.30V	.1	
619	NPN.SI.SW	SAT	JANTX	058E	.03042	0	25	500MW.40V	.033	
563	NPN.SI.SW	SAT	JANTX	058E	.01738	0	25	360MW.30V	.1	
562	NPN.SI.SW	SAT	JANTX	058E	.14776	0	25	360MW.50V	.132	
607	NPN.SI.SW	SAT	JANTX	058E	.00869	0	25	360MW.40V	.053	
627	NPN.SI.SW	SAT	JANTX	058E	.04243	0	25	15W.80V	.125	
603	NPN.SI.SW	SAT	JANTX	058E	.03477	0	25	500MW.40V	.068	
554	NPN.SI.SW	SAT	JANTX	058E	.03477	0	25	360MW.40V	.1	
570	NPN.SI.SW	SAT	JANTX	058E	.09996	0	25	500MW.40V	.035	
625	NPN.SI.SW	SAT	JANTX	058E	.02122	0	25	15W.80V	.1	
584	NPN.SI.SW	SAT	JANTX	058E	.03911	0	25	500MW.40V	.1	
686	NPN.SI.SW	SAT	JANTX	058E	.00257	0	25	300MW.45V	.1	
631	NPN.SI.SW	SAT	JANTX	058E	.24338	0	25	360MW.30V	.025	
639	NPN.SI.SW	SAT	JANTX	058E	.113	0	25	360MW.40V	.073	
650	NPN.SI.SW	SAT	JANTX	058E	.02122	0	25	15W.80V	.1	
549	NPN.SI.SW	SAT	JANTX	058E	.00486	0	25	15W.80V	.122	
550	NPN.SI.SW	SAT	JANTX	058E	.03477	0	25	200MW.30V	.1	
672	NPN.SI.SW	SAT	JANTX	058E	.01738	0	25	15W.80V	.1	
670	NPN.SI.SW	SAT	JANTX	058E	.01061	0	25	15W.80V	.1	
660	NPN.SI.SW	SAT	JANTX	058E	.12169	0	25	360MW.40V	.087	
663	NPN.SI.SW	SAT	JANTX	058E	.06954	0	25	360MW.30V	.08	
638	NPN.SI.SW	SAT	JANTX	058E	.01738	0	25	500MW.40V	.085	
523	NPN.SI.SW	SAT	JANTX	058A	6.108	0	25	300MW.15V	.1	
604	NPN.SI.SW	SAT	JANTX	058E	.04781	0	25	500MW.40V	.12	
608	NPN.SI.SW	SAT	JANTX	058E	.01738	0	25	500MW.40V	.058	
665	NPN.SI.SW	SAT	JANTX	058E	.00435	0	25	300MW.30V	.03	

48.TOTAL 31.0322 MILLION HOURS 0 FAILURES RATE IS 0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SPCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
343	NPN.SI.SW	SUB	JAN	051B	824.412	0	35	.5W	.2	
348	NPN.SI.SW	SUB	JAN	051B	11.845	1	35	25W	.2	
344	NPN.SI.SW	SUB	JAN	051B	82.915	0	35	.125W	.2	
338	NPN.SI.SW	SUB	JAN	051B	66.332	0	35	1W	.2	
362	NPN.SI.SW	SUB	JAN	051B	367.195	1	35	.6W	.2	
363	NPN.SI.SW	SUB	JAN	051B	71.07	0	35	.8W	.2	
368	NPN.SI.SW	SUB	JAN	051B	1762.536	9	35	.8W	.2	
350	NPN.SI.SW	SUB	JAN	051B	7.107	0	35	.8W	.2	
346	NPN.SI.SW	SUB	JAN	051B	18.952	0	35	.3W	.2	
352	NPN.SI.SW	SUB	JAN	051B	317.446	1	35	.5W	.2	
361	NPN.SI.SW	SUB	JAN	051B	9.476	2	35	.6W	.2	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
354	NPN.SI.SW	SUB	JAN	0510	7.107	0	35	.3W	.2	
349	NPN.SI.SW	SUB	JAN	0510	71.07	0	35	25W	.2	
347	NPN.SI.SW	SUB	JAN	0510	204.20	2	35	.8W	.2	
	49. TOTAL	3901.74	MILLION HOURS			16	FAILURES		RATE IS	.410073E-2 FAIL/10**6HRS
327	NPN.SI.SW	SUB	JANTX	0510	9.476	0	35	.36W	.2	
	50. TOTAL	9.476	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
336	NPN.SI.SW	SUB	LOWER	0510	20.420	0	35	.5W	.2	
335	NPN.SI.SW	SUB	LOWER	0510	26.059	0	35	.3W	.2	
333	NPN.SI.SW	SUB	LOWER	0510	42.642	0	35	2W	.2	
334	NPN.SI.SW	SUB	LOWER	0510	9.476	0	35	.3W	.2	
	51. TOTAL	106.605	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
103	NPN.SI.U	AI	JANTX	045	.004	0	55	.25 W. 15 V	.03. .04 V	
61	NPN.SI.U	AI	JANTX	045	.004	0	55	2.93 W. 50 V	0.0. .050 V	
64	NPN.SI.U	AI	JANTX	045	.004	0	55	4.1 W. 350 V	.001. .411 V	
63	NPN.SI.U	AI	JANTX	045	.004	0	55	2.93 W. 45 V	.005. .116 V	
89	NPN.SI.U	AI	JANTX	045	.004	0	55	135 W. 150 V	.06. .07 V	
94	NPN.SI.U	AI	JANTX	045	.004	0	55	1.30 W. 50 V	.004. .23 V	
100	NPN.SI.U	AI	JANTX	045	.004	0	55	4 W. 100 V	.05. .46 V	
95	NPN.SI.U	AI	JANTX	045	.004	0	55	3.64 W. 350 V	.01. .41V	
256	NPN.SI.U	AI	JANTX	045	.004	0	55	4.3W.350V	.009..411V	
91	NPN.SI.U	AI	JANTX	045	.004	0	55	24.5 W. 140 V	.06. .16 V	
59	NPN.SI.U	AI	JANTX	045	.004	0	55	2.15 W. 50 V	.004. .24 V	
101	NPN.SI.U	AI	JANTX	045	.004	0	55	4 W. 100 V	.04. .32 V	
86	NPN.SI.U	AI	JANTX	045	.004	0	55	.50 W. 60 V	0.0. .23 V	
90	NPN.SI.U	AI	JANTX	045	.004	0	55	3.92 W. 40 V	.01. .15 V	
93	NPN.SI.U	AI	JANTX	045	.004	0	55	.37 W. 50 V	0.0. .1 V	
99	NPN.SI.U	AI	JANTX	045	.004	0	55	4 W.350 V	0.0. .26 V	
257	NPN.SI.U	AI	JANTX	045	.004	0	55	2.93W.50V	0..30V	
98	NPN.SI.U	AI	JANTX	045	.004	0	55	24.5 W. 140 V	.08. .16 V	
62	NPN.SI.U	AI	JANTX	045	.004	0	55	2.93 W. 45 V	.005. .111 V	
60	NPN.SI.U	AI	JANTX	045	.004	0	55	2.93 W. 50 V	0.0. .23 V	
144	NPN.SI.U	AI	JANTX	045	.004	0	55	19.06 W. 140 V	.049. .021 V	
92	NPN.SI.U	AI	JANTX	045	.004	0	55	.023 W. 15 V	.21. .11 V	
102	NPN.SI.U	AI	JANTX	045	.004	0	55	4 W. 150 V	.03. .51 V	
	52. TOTAL	.092	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
408	NPN.SI.U	AU	JANTXV	059	8.388	0	40	.5W		
	53. TOTAL	8.388	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
487	NPN.SI.U	GB	JANTXV	0570	7.546	0	37		.7	
	54.TOTAL	7.546 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
725	NPN.SI.U	GF	LOWER	063	2.95	13	30		.8	PWR
717	NPN.SI.U	GF	LOWER	063	7.54	20	30		.3	
715	NPN.SI.U	GF	LOWER	063	65.99	13	30		.1	
724	NPN.SI.U	GF	LOWER	063	4.12	9	30		.5	PWR
718	NPN.SI.U	GF	LOWER	063	5.86	9	30	<=1W	.7	
716	NPN.SI.U	GF	LOWER	063	24.39	1	30		.2	
722	NPN.SI.U	GF	LOWER	063	7.06	16	30		.2	PWR
721	NPN.SI.U	GF	LOWER	063	11.90	45	30		.1	PWR
723	NPN.SI.U	GF	LOWER	063	2.94	11	30		.3	PWR
127	NPN.SI.U	GF	LOWER	053	1200	790	55		.5	SMALL SIG
233	NPN.SI.U	GF	LOWER	053	16	8	55		.5	DARLINGTON
129	NPN.SI.U	GF	LOWER	053	537	828	55		.5	PWR
	55.TOTAL	1893.75 MILLION HOURS				1771 FAILURES			RATE IS	.935102 FAIL/10**6HRS
128	NPN.SI.U	GF	PLASTIC	053	3021	1398	55		.5	SMALL SIG
130	NPN.SI.U	GF	PLASTIC	053	130	315	55		.5	PWR
	56. TOTAL	3151 MILLION HOURS				1713 FAILURES			RATE IS	.543637 FAIL/10**6HRS
385	NPN.SI.U	GM	LOWER	054	.139	0	30		.8	
496	NPN.SI.U	GM	LOWER	054	.056	0	30		.8	DUAL
	57. TOTAL	.195 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
595	NPN.SI.U	SAT	JANTX	050E	.02122	0	25	115W.60V	.1	
596	NPN.SI.U	SAT	JANTX	050E	.03477	0	25	225MW.40V	.1	
573	NPN.SI.U	SAT	JANTX	050E	.02122	0	25	80W.150V	.017	
613	NPN.SI.U	SAT	JANTX	050E	.01061	0	25	15W.80V	.1	
542	NPN.SI.U	SAT	JANTX	050E	.1273	0	25	1W.80V	.052	
543	NPN.SI.U	SAT	JANTX	050E	.2521	0	25	225MW.60V	.1	
547	NPN.SI.U	SAT	JANTX	050E	.04243	0	25	15W.80V	.1	
597	NPN.SI.U	SAT	JANTX	050E	.04243	0	25	15W.100V	.1	
540	NPN.SI.U	SAT	JANTX	050E	.03477	0	25	225MW.40V	.1	
592	NPN.SI.U	SAT	JANTX	050E	.13030	0	25	225MW.60V	.1	
620	NPN.SI.U	SAT	JANTX	050E	.01730	0	25	200MW.30V	.1	
561	NPN.SI.U	SAT	JANTX	050E	.01061	0	25	53W.80V	.1	
133	NPN.SI.U	SAT	JANTX	052	316.33	0	25		.2	
646	NPN.SI.U	SAT	JANTX	050E	.13907	0	25	225MW.60V	.080	
566	NPN.SI.U	SAT	JANTX	050E	.02122	0	25	3.5W.14V	.133	
609	NPN.SI.U	SAT	JANTX	050E	.06954	0	25	225MW.60V	.1	
614	NPN.SI.U	SAT	JANTX	050E	.01730	0	25	225MW.40V	.1	
587	NPN.SI.U	SAT	JANTX	050E	.5650	0	25	200MW.30V	.1	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
572	NPN.SI.U	SAT	JANTX	050E	.06365	0	25	70W.80V	.14	
666	NPN.SI.U	SAT	JANTX	050E	.06004	0	25	225MW.60V	.1	
634	NPN.SI.U	SAT	JANTX	050E	.03477	0	25	200MW.30V	.1	
631	NPN.SI.U	SAT	JANTX	050E	.01730	0	25	225MW.40V	.1	
626	NPN.SI.U	SAT	JANTX	050E	.01730	0	25	225MW.40V	.1	
671	NPN.SI.U	SAT	JANTX	050E	.02122	0	25	225MW.40V	.1	
621	NPN.SI.U	SAT	JANTX	050E	.13030	1	25	225MW.60V	.1	
571	NPN.SI.U	SAT	JANTX	050E	.21216	0	25	53W.80V	.012	
567	NPN.SI.U	SAT	JANTX	050E	.01061	0	25	25W.30V	.191	
	58. TOTAL	318.456	MILLION HOURS			1	FAILURES		RATE IS	.314015E-2 FAIL/10**6HRS
151	NPN.SI.U	SUB	JAN	014	2371.50	25	40		.2	
152	NPN.SI.U	SUB	JAN	014	414.301	11	45		.2	
	59. TOTAL	2785.80	MILLION HOURS			36	FAILURES		RATE IS	.129223E-1 FAIL/10**6HRS
500	PNP.GER	NS	JAN	032AG	.234	0	40		.3	
	60. TOTAL	.234	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
474	PNP.GER.LIN	GF	JAN	055B	7.998	0	30	1W	.25-.5	
	61. TOTAL	7.998	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
598	PNP.GER.LIN	SAT	JANTX	050E	.01304	0	25	50W.40V	.063	
	62. TOTAL	.01304	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
469	PNP.GER.LIN	SUB	JAN	051B	18.952	0	35	0.5W	.3	
470	PNP.GER.LIN	SUB	JAN	051B	371.933	0	35	.225W	.3	
472	PNP.GER.LIN	SUB	JAN	051B	2.369	0	35	90W	.3	
	63. TOTAL	393.254	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
475	PNP.GER.SW	GF	JAN	055B	6.307	0	30	1W	.25-.5	
476	PNP.GER.SW	GF	JAN	055B	.046	0	30	60W	.25-.5	
473	PNP.GER.SW	GF	JAN	055A	1.328	0	35	.15AW	.25-.5	
	64. TOTAL	7.681	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
465	PNP.GER.SW	GF	JANTX	051C	.095	0	25	100W	.2	
	65. TOTAL	.095	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
479	PNP.GER.SW	GM	JAN	054	.042	0	30	100W	.8	
466	PNP.GER.SW	GM	JAN	054	.167	0	30	100W	.8	
	66. TOTAL	.209	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SPCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
477	PNP.GER.SW	GM	LOWER	054	.167	0	30	100W		
467	PNP.GER.SW	GM	LOWER	054	.167	0	30	100W	.8	
478	PNP.GER.SW	GM	LOWER	054	.270	0	30	100W	.8	
	67. TOTAL	.612 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
464	PNP.GER.SW	NS	JANTX	051C	.039	0	35	100W	.2	
	68. TOTAL	.039 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
468	PNP.GER.SW	SUB	JAN	051B	293.756	2	35	100W	.2	
471	PNP.GER.SW	SUB	JAN	051B	123.188	8	35	70W	.2	
	69. TOTAL	416.944 MILLION HOURS				10 FAILURES			RATE IS	.023984 FAIL/10**6HRS
498	PNP.SI	NS	JAN	032AG	4.564	0	40			
	70. TOTAL	4.564 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
512	PNP.SI.DUAL	GF	JAN	049A	3.039	1	35		.5	
	71. TOTAL	3.039 MILLION HOURS				1 FAILURES			RATE IS	.260485 FAIL/10**6HRS
738	PNP.SI.LIN	AI	JANTX	049	.149	0	45	1W	.5	
	72. TOTAL	.149 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
453	PNP.SI.LIN	AU	JANTX	056	.001184	0	30	.4W		
	73. TOTAL	.001184 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
132	PNP.SI.LIN	GB	JANTXV	051A	3743.24	2	10	360MW,15V	.5	
	74. TOTAL	3743.24 MILLION HOURS				2 FAILURES			RATE IS	.534297E-3 FAIL/10**6HRS
423	PNP.SI.LIN	GF	JAN	055B	.184	0	30	40W	.25-.5	
421	PNP.SI.LIN	GF	JAN	055B	.414	0	30	1W	.25-.5	
420	PNP.SI.LIN	GF	JAN	055A	.016	0	35	30W	.25-.5	
418	PNP.SI.LIN	GF	JAN	055A	2.005	6	35	5W	.25-.5	
416	PNP.SI.LIN	GF	JAN	055A	24.507	10	35	2W,450V	.25-.5	
	75. TOTAL	27.126 MILLION HOURS				16 FAILURES			RATE IS	.58984 FAIL/10**6HRS
400	PNP.SI.LIN	GF	JANTX	051C	.095	0	25	1W	.3	
398	PNP.SI.LIN	GF	JANTX	051C	.007	0	25	1W	.3	
404	PNP.SI.LIN	GF	JANTX	051C	.138	0	25	25W	.3	
402	PNP.SI.LIN	GF	JANTX	051C	.064	0	25	150W	.3	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10↑6	FAIL	TEMP	RATING	STRESS	COMMENTS
186	PNP.SI.LIN	GF	JANTX	049	.597	0	45	1W	.5	
76.TOTAL		.901 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
406	PNP.SI.LIN	GF	LOWER	051C	.1	0	25	150W	.3	
495	PNP.SI.LIN	GF	LOWER	053	9	7	55		.5	DUAL
77.TOTAL		9.1 MILLION HOURS				7 FAILURES			RATE IS	.769231 FAIL/10**6HRS
426	PNP.SI.LIN	GM	JAN	054	.270	0	30	.5W	.8	
425	PNP.SI.LIN	GM	JAN	054	.020	0	30	1W	.8	
78. TOTAL		.306 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
701	PNP.SI.LIN	GM	JANTX	066	.4165	0	30	150W.80V		
79. TOTAL		.4165 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
700	PNP.SI.LIN	GM	LOWER	066	.1250	0	30	200MW.30V		
705	PNP.SI.LIN	GM	LOWER	066	.0200	0	30	360MW.80V		
80. TOTAL		.1450 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
403	PNP.SI.LIN	NS	JANTX	051C	.059	0	35	25W	.3	
399	PNP.SI.LIN	NS	JANTX	051C	.039	0	35	1W	.3	
397	PNP.SI.LIN	NS	JANTX	051C	.003	0	35	1W	.3	
401	PNP.SI.LIN	NS	JANTX	051C	.026	0	35	150W	.3	
81.TOTAL		.127 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
405	PNP.SI.LIN	NS	LOWER	051C	.046	0	35	150W	.3	
82.TOTAL		.046 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
581	PNP.SI.LIN	SAT	JANTX	050E	.06954	0	25	500MW.80V	.1	
675	PNP.SI.LIN	SAT	JANTX	050E	.02600	0	25	800MW.80V	.1	
569	PNP.SI.LIN	SAT	JANTX	050E	.03911	0	25	400MW.40V	.001	
656	PNP.SI.LIN	SAT	JANTX	050E	.01061	0	25	25W.80V	.32	
559	PNP.SI.LIN	SAT	JANTX	050E	.03477	0	25	800MW.80V	.1	
641	PNP.SI.LIN	SAT	JANTX	050E	.02600	0	25	500MW.60V	.095	
632	PNP.SI.LIN	SAT	JANTX	050E	.04346	0	25	600MW.40V	.004	
645	PNP.SI.LIN	SAT	JANTX	050E	.113	0	25	500MW.60V	.05	
635	PNP.SI.LIN	SAT	JANTX	050E	.02600	0	25	200MW.30V	.04	
591	PNP.SI.LIN	SAT	JANTX	050E	.017384	0	25	360MW.40V	.1	
83.TOTAL		.406114 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
437	PNP.SI.LIN	SUB	JAN	051B	106.605	0	35	.5W	.3	
412	PNP.SI.LIN	SUB	JAN	051B	4.738	0	35	.305W	.3	
413	PNP.SI.LIN	SUB	JAN	051B	26.059	0	35	.305W	.3	
430	PNP.SI.LIN	SUB	JAN	051B	14.214	0	35	.25W	.3	
431	PNP.SI.LIN	SUB	JAN	051B	149.247	0	35	.25W	.3	
	84.TOTAL	300.863 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
414	PNP.SI.LIN	SUB	LOWER	051B	26.059	0	35	.4W	.3	
	85. TOTAL	26.059 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
504	PNP.SI.LIN.DUAL	GF	JAN	049A	12.07	0	35		.5	
	86. TOTAL	12.07 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
541	PNP.SI.LIN.DUAL	SAT	JANTX	050E	.0522	0	25	250MW.60V	.002	PWR IS GIVEN PER SIDE
500	PNP.SI.LIN.DUAL	SAT	JANTX	050E	.008692	0	25	400MW.60V	.1	
	87. TOTAL	.060892 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
411	PNP.SI.LINSW	SUB	JAN	051B	409.837	0	35	.4W	.2	
	88. TOTAL	409.837 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
203	PNP.SI.PWR	GF	JAN	055A	2.902	0	35		.25-.5	
	89. TOTAL	2.902 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
741	PNP.SI.SW	AI	JANTX	049	.298	0	45	40W	.5	
739	PNP.SI.SW	AI	JANTX	049	.696	0	45	.36W	.5	
740	PNP.SI.SW	AI	JANTX	049	1.492	0	45	1.0W	.5	
	90. TOTAL	2.486 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
455	PNP.SI.SW	AU	JANTX	056	.007716	0	30	1.0W		
457	PNP.SI.SW	AU	JANTX	056	.000140	0	30	2W		
454	PNP.SI.SW	AU	JANTX	056	.000592	0	30	3W		
456	PNP.SI.SW	AU	JANTX	056	.001529	0	30	.4W		
458	PNP.SI.SW	AU	JANTX	056	.001036	0	30	.4W		
460	PNP.SI.SW	AU	JANTX	059	.432	0	40	.36W		
461	PNP.SI.SW	AU	JANTX	059	.048	0	40	10W		
462	PNP.SI.SW	AU	JANTX	059	.048	0	40	10W		
	91. TOTAL	.539021 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
744	PNP.SI.SW	GB	JANTXV	051A	2973.10	2	10	1.0W.40V	.5	
	92. TOTAL	2973.1 MILLION HOURS				2 FAILURES			RATE IS	.672699E-3 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
210	PNP.SI.SW	GF	JAN	044A	1379	275	25	1W	.3	
211	PNP.SI.SW	GF	JAN	044A	1103	16	25	.36W	.3	
422	PNP.SI.SW	GF	JAN	055B	119.105	11	30	1W	.25-.5	
511	PNP.SI.SW	GF	JAN	049A	32.636	1	35		.5	
507	PNP.SI.SW	GF	JAN	049A	45.665	0	35		.5	
503	PNP.SI.SW	GF	JAN	049A	4.602	0	35		.5	
505	PNP.SI.SW	GF	JAN	049A	3.017	1	35		.5	
509	PNP.SI.SW	GF	JAN	049A	407.112	3	35	1.0W	.5	
508	PNP.SI.SW	GF	JAN	049A	130.502	0	35	.36W	.5	
506	PNP.SI.SW	GF	JAN	049A	415.451	0	35		.5	
419	PNP.SI.SW	GF	JAN	055A	3.222	0	35	6W	.25-.5	
513	PNP.SI.SW	GF	JAN	049A	15.350	0	35		.5	
417	PNP.SI.SW	GF	JAN	055A	1507.646	10	35	<5W	.25-.5	
	93. TOTAL	5254.4 MILLION HOURS				317 FAILURES			RATE IS	.603304E-1 FAIL/10**6HRS
450	PNP.SI.SW	GF	JANTX	051C	.046	0	25	1W	.2	
442	PNP.SI.SW	GF	JANTX	051C	.095	0	25	1.0W	.2	
444	PNP.SI.SW	GF	JANTX	051C	.046	0	25	3W	.2	
440	PNP.SI.SW	GF	JANTX	051C	.313	0	25	2W	.2	
446	PNP.SI.SW	GF	JANTX	051C	.032	0	25	1W	.2	
448	PNP.SI.SW	GF	JANTX	051C	.610	0	25	1.0W	.2	
188	PNP.SI.SW	GF	JANTX	049	5.966	0	45	1.0W	.5	
187	PNP.SI.SW	GF	JANTX	049	2.704	0	45	.36W	.5	
189	PNP.SI.SW	GF	JANTX	049	1.194	0	45	40W	.5	
	94. TOTAL	11.094 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
720	PNP.SI.SW	GF	JANTXV	060	.205112	0	30	3W	<.3	
	95. TOTAL	.205112 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
410	PNP.SI.SW	GM	JAN	054	.610	0	30	.36W	.8	
452	PNP.SI.SW	GM	JAN	054	.139	0	30	2W	.8	
409	PNP.SI.SW	GM	JAN	054	.035	0	30	.4W	.8	
427	PNP.SI.SW	GM	JAN	054	1.600	0	30	1W	.8	
420	PNP.SI.SW	GM	JAN	054	.146	0	30	.36W	.8	
407	PNP.SI.SW	GM	JAN	054	.479	0	30	3W	.8	
451	PNP.SI.SW	GM	JAN	054	2.720	0	30	1W	.8	
	96. TOTAL	5.825 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
697	PNP.SI.SW	GM	JANTX	066	.1249	0	30	3W,60V		
699	PNP.SI.SW	GM	JANTX	066	1.2496	1	30	1.0W,60V		
698	PNP.SI.SW	GM	JANTX	066	.0416	0	30	1.0W,40V		
	97. TOTAL	1.4161 MILLION HOURS				1 FAILURES			RATE IS	.706165 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10+6	FAIL	TEMP	RATING	STRESS	COMMENTS
424	PNP.SI.SW	GM	LOWER	054	.028	0	30	6W	.8	
707	PNP.SI.SW	GM	LOWER	066	.0729	0	30	310MW,40V		
710	PNP.SI.SW	GM	LOWER	066	.0208	0	30	6W,60V		
98.	TOTAL	.1217	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
449	PNP.SI.SW	NS	JANTX	051C	.020	0	35	1W	.2	
439	PNP.SI.SW	NS	JANTX	051C	.252	0	35	1.8W	.2	
445	PNP.SI.SW	NS	JANTX	051C	.013	0	35	1W	.2	
443	PNP.SI.SW	NS	JANTX	051C	.02	0	35	3W	.2	
447	PNP.SI.SW	NS	JANTX	051C	.124	0	35	2W	.2	
441	PNP.SI.SW	NS	JANTX	051C	.039	0	35	1.8W	.2	
99.	TOTAL	.468	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
550	PNP.SI.SW	SAT	JANTX	050E	.000692	0	25	3W,60V	.1	
630	PNP.SI.SW	SAT	JANTX	050E	.07023	0	25	400MW,60V	.03	
556	PNP.SI.SW	SAT	JANTX	050E	.04346	0	25	360MW,60V	.001	
640	PNP.SI.SW	SAT	JANTX	050E	.15912	0	25	360MW,40V	.106	
657	PNP.SI.SW	SAT	JANTX	050E	.00069	0	25	600MW,35V	.3	
662	PNP.SI.SW	SAT	JANTX	050E	.01738	0	25	400MW,60V	.04	
674	PNP.SI.SW	SAT	JANTX	050E	.00435	0	25	360MW,60V	.1	
679	PNP.SI.SW	SAT	JANTX	050E	.12603	0	25	1.0W,60V	.017	
673	PNP.SI.SW	SAT	JANTX	050E	.09996	0	25	1.0W,60V	.099	
605	PNP.SI.SW	SAT	JANTX	050E	.03042	0	25	1.0W,60V	.13	
677	PNP.SI.SW	SAT	JANTX	050E	.00065	0	25	3W,60V	.103	
609	PNP.SI.SW	SAT	JANTX	050E	.00069	0	25	360MW,60V	.1	
522	PNP.SI.SW	SAT	JANTX	050A	6.108	0	25	250MW,8V	.1	
560	PNP.SI.SW	SAT	JANTX	050E	.06519	0	25	1.0W,60V	.045	
602	PNP.SI.SW	SAT	JANTX	050E	.00069	0	25	1.0W,60V	.02	
600	PNP.SI.SW	SAT	JANTX	050E	.04346	0	25	300MW,15V	.097	
557	PNP.SI.SW	SAT	JANTX	050E	.27014	0	25	1.0W,60V	.097	
618	PNP.SI.SW	SAT	JANTX	050E	.02600	0	25	1.0W,60V	.002	
633	PNP.SI.SW	SAT	JANTX	050E	.01738	0	25	300MW,15V	.03	
535	PNP.SI.SW	SAT	JANTX	050A	91.62	0	25	1.0W,40V	.1	
534	PNP.SI.SW	SAT	JANTX	050A	8.144	0	25	600MW,35V	.1	
608	PNP.SI.SW	SAT	JANTX	050E	.03042	0	25	400MW,10V	.1	
655	PNP.SI.SW	SAT	JANTX	050E	.33099	0	25	360MW,40V	.001	
604	PNP.SI.SW	SAT	JANTX	050E	.01061	0	25	1.0W,40V	.09	
545	PNP.SI.SW	SAT	JANTX	050E	.1043	0	25	200MW,40V	.15	
576	PNP.SI.SW	SAT	JANTX	050E	.25207	0	25	400MW,60V	.1	
100.	TOTAL	107.641	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
436	PNP.SI.SW	SUB	JAN	051B	160.199	0	35	.36W	.2	
430	PNP.SI.SW	SUB	JAN	051B	14.214	0	35	1W	.2	
434	PNP.SI.SW	SUB	JAN	051B	33.166	0	35	3W	.2	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE.	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
432	PNP.SI.SW	SUB	JAN	0510	130.295	2	35	1.0W	.2	
433	PNP.SI.SW	SUB	JAN	0510	132.664	1	35	3W	.2	
435	PNP.SI.SW	SUB	JAN	0510	153.985	4	35	.36W	.2	
429	PNP.SI.SW	SUB	JAN	0510	022.043	11	35	.6W	.2	
	101. TOTAL	1454.57	MILLION HOURS			18	FAILURES		RATE IS	.123740E-1 FAIL/10**6HRS
415	PNP.SI.SW	SUB	LOWER	0510	35.535	0	35	.3W	.3	
	102. TOTAL	35.535	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
510	PNP.SI.SW.HV	GF	JAN	049A	9.205		35		.5	
	103. TOTAL	9.205	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
193	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.04V	
179	PNP.SI.U	AI	JANTX	045	.0038	0	55	.95W.60V	0.0..04V	
190	PNP.SI.U	AI	JANTX	045	.0038	0	55	.00W.60V	.02,.37V	
195	PNP.SI.U	AI	JANTX	045	.0038	0	55	1W.40V	.4,.32V	
174	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.05V	
167	PNP.SI.U	AI	JANTX	045	.0038	0	55	7.3W.300V	.01, .40 V	
171	PNP.SI.U	AI	JANTX	045	.0038	0	55	2.4W.60V	.012,.017V	
160	PNP.SI.U	AI	JANTX	045	.0038	0	55	.94 W. 60 V	0.0..27V	
170	PNP.SI.U	AI	JANTX	045	.0038	0	55	2.36W.60V	0.0..012V	
173	PNP.SI.U	AI	JANTX	045	.0038	0	55	0.1W.300V	.01,.40V	
178	PNP.SI.U	AI	JANTX	045	.0038	0	55	.94W.60V	0.0..04V	
197	PNP.SI.U	AI	JANTX	045	.0038	0	55	5W.60V	.00,..21V	
191	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.37V	
175	PNP.SI.U	AI	JANTX	045	.0038	0	55	.957W.60V	0.0..09V	
172	PNP.SI.U	AI	JANTX	045	.0038	0	55	2.4W.60V	0.0..012V	
194	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.25V	
192	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.37V	
177	PNP.SI.U	AI	JANTX	045	.0038	0	55	.96W.60V	.13,.10V	
190	PNP.SI.U	AI	JANTX	045	.0038	0	55	20W.60V	0.0..16V	
200	PNP.SI.U	AI	JANTX	045	.0038	0	55	.94W.60V	0.0..01V	
196	PNP.SI.U	AI	JANTX	045	.0038	0	55	36W.60V	0.0..1V	
180	PNP.SI.U	AI	JANTX	045	.0038	0	55	60V	.05V	
201	PNP.SI.U	AI	JANTX	045	.0038	0	55	7.7W.300V	.01,.40V	
169	PNP.SI.U	AI	JANTX	045	.0038	0	55	20W.50V	.01,.04V	
199	PNP.SI.U	AI	JANTX	045	.0038	0	55	.94W. 60V	0.0. .1V	
176	PNP.SI.U	AI	JANTX	045	.0038	0	55	7.7W.40V	.05,.32V	
	104. TOTAL	.0988	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
459	PNP.SI.U	AU	JANTX	059	1.104	0	40	10W		
463	PNP.SI.U	AU	JANTX	059	2.676	0	40	.4W		
	105. TOTAL	3.78	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10+6	FAIL	TEMP	RATING	STRESS	COMMENTS
748	PNP.SI.U	GB	JANTXV	051A	125.372	0	10		.5	
	106. TOTAL	125.372 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
720	PNP.SI.U	GF	LOWER*	063	5.1	1	30	<=1W	.2	
719	PNP.SI.U	GF	LOWER	063	44.12	3	30	<=1W	.1	
726	PNP.SI.U	GF	LOWER	063	10.60	55	30		.1	PWR
727	PNP.SI.U	GF	LOWER	063	4.60	9	30		.2	PWR
204	PNP.SI.U	GF	LOWER	053	950	674	55		.5	SMALL SIG
234	PNP.SI.U	GF	LOWER	053	8	5	55		.5	DARLINGTON
206	PNP.SI.U	GF	LOWER	053	118	231	55		.5	PWR
	107. TOTAL	1140.42 MILLION HOURS				978 FAILURES			RATE IS	.857579 FAIL/10**6HRS
207	PNP.SI.U	GF	PLASTIC	053	70	106	55	•	.5	PWR
205	PNP.SI.U	GF	PLASTIC	053	1866	997	55		.5	SMALL SIG
	108. TOTAL	1936 MILLION HOURS				1103 FAILURES			RATE IS	.569731 FAIL/10**6HRS
649	PNP.SI.U	SAT	JANTX	050E	.05215	0	25	225MW,40V	.1	
546	PNP.SI.U	SAT	JANTX	050E	.1043	0	25	225MW,40V	.1	
612	PNP.SI.U	SAT	JANTX	050E	.02600	0	25	225MW,40V	.1	
622	PNP.SI.U	SAT	JANTX	050E	.06954	0	25	225MW,60V	.1	
647	PNP.SI.U	SAT	JANTX	050E	.06954	0	25	225MW,60V	.1	
667	PNP.SI.U	SAT	JANTX	050E	.03477	0	25	225MW,60V	.1	
623	PNP.SI.U	SAT	JANTX	050E	.05215	0	25	200MW,40V	.15	
586	PNP.SI.U	SAT	JANTX	050E	1.1734	0	25	200MW,40V	.1	
610	PNP.SI.U	SAT	JANTX	050E	.03477	0	25	225MW,60V	.1	
624	PNP.SI.U	SAT	JANTX	050E	.05215	0	25	225MW,40V	.1	
669	PNP.SI.U	SAT	JANTX	050E	.02600	0	25	225MW,40V	.1	
611	PNP.SI.U	SAT	JANTX	050E	.02600	0	25	200MW,40V	.133	
593	PNP.SI.U	SAT	JANTX	050E	.06954	0	25	225MW,60V	.1	
209	PNP.SI.U	SAT	JANTX	052	386.830	0	25		.2	
640	PNP.SI.U	SAT	JANTX	050E	.05215	0	25	200MW,40V	.15	
660	PNP.SI.U	SAT	JANTX	050E	.02600	0	25	200MW,40V	.133	
594	PNP.SI.U	SAT	JANTX	050E	.05215	0	25	225MW,40V	.1	
544	PNP.SI.U	SAT	JANTX	050E	.1391	0	25	225MW,60V	.1	
	109. TOTAL	388.89 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
202	PNP.SI.U	SUB	JAN	014	1368.84	13	40	1W		
203	PNP.SI.U	SUB	JAN	014	6	0	45	1		
	110. TOTAL	1374.84 MILLION HOURS				13 FAILURES			RATE IS	.945565E-2 FAIL/10**6HRS
742	UJT	AI	JANTX	049	.149	0	45	.45W	.5	
	111. TOTAL	.149 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
493	UJT	GF	JAN	055B	4.024	0	30	.45W	.25-.5	UNIJUNCTION
491	UJT	GF	JAN	055A	1.451	0	35		.25-.5	UNIJUNCTION
492	UJT	GF	JAN	055A	13.812	4	35	.45W	.25-.5	UNIJUNCTION
	112.TOTAL	19.287 MILLION HOURS				4 FAILURES			RATE IS	.207394 FAIL/10**6HRS
230	UJT	GF	JANTX	049	.597	0	45	.45W	.5	
	113.TOTAL	.597 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
711	UJT	GM	LOWER	066	.0104	0	30			
709	UJT	GM	LOWER	066	.0208	0	30			
	114.TOTAL	.0312 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
502	UJT	NS	JAN	032AG	.051	0	40			
	115.TOTAL	.051 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
231	UJT	SAT	JANTX	052	1.64	0	25		.2	
607	UJT	SAT	JANTX	050E	.005	0	25		.1	
582	UJT	SAT	JANTX	050E	.08	0	25	300MW	.1	
	116.TOTAL	1.725 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

APPENDIX C

INTERMEDIATE DATA SUMMARY - DIODES

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
476	FAST RECOV	GF	JAN	049A	17.278	0	35		.5	
474	FAST RECOV	GF	JAN	049A	5.759	0	35		.5	
464	FAST RECOV	GF	JAN	049A	82.721	5	35		.5	
1.	TOTAL				105.758 MILLION HOURS	5 FAILURES			RATE IS	.472777E-1 FAIL/10**6HRS
481	FAST RECOV	GF	JANTX	049	.746	0	45		.5	GF 80%. AI 20%
2.	TOTAL				.746 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
450	GER.GP	NS	JAN	032AG	1.260	0	40			
3.	TOTAL				1.26 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
395	GER.GP.SIG	GF	JANTX	055A	2.902	0	35			
393	GER.GP.SIG	GF	JANTX	055A	.033	0	35			
394	GER.GP.SIG	GF	JANTX	055A	.6	0	35			
4.	TOTAL				3.535 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
391	GER.GP.SIG	SUB	JAN	051B	61.594	0	35	.2A	.2	
392	GER.GP.SIG	SUB	JAN	051B	1165.548	4	35	.1A	.2	
5.	TOTAL				1227.14 MILLION HOURS	4 FAILURES			RATE IS	.325961E-2 FAIL/10**6HRS
402	PIN	GF	JAN	044A	8291.84	1298	25		.3PWR	
6.	TOTAL				8291.84 MILLION HOURS	1298 FAILURES			RATE IS	.156539 FAIL/10**6HRS
406	PIN	GF	JANTX	055A	1.134	0	35			
405	PIN	GF	JANTX	055A	5.418	1	35			
404	PIN	GF	JANTX	055A	.120	0	35			
403	PIN	GF	JANTX	055A	.938	0	35			
7.	TOTAL				7.61 MILLION HOURS	1 FAILURES			RATE IS	.131406 FAIL/10**6HRS
408	SCHOTTKY	GF	JAN	044A	1.503	0	25		.4	
8.	TOTAL				1.503 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
135	SCHOTTKY	GF	JANTX	055A	4.917	0	35	22A	.2	
9.	TOTAL				4.917 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
407	SCHOTTKY	GF	LOWEP	053	351	85	55		.3	
10.	TOTAL				351 MILLION HOURS	85 FAILURES			RATE IS	.242165 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10+6	FAIL	TEMP	RATING	STRESS	COMMENTS
433	SCHOTTKY	SAT	JANTX	058C	.0706	0	25			
501	SCHOTTKY	SAT	JANTX	058D	.0575	0	25			
574	SCHOTTKY	SAT	JANTX	058E	.01000	0	25		.100	
564	SCHOTTKY	SAT	JANTX	058E	.06000	0	25		.100	
534	SCHOTTKY	SAT	JANTX	058E	.04000	0	25		.100	
492	SCHOTTKY	SAT	JANTX	058B	.157	0	25			
515	SCHOTTKY	SAT	JANTX	058E	.0400	0	25		.100	
11.	TOTAL	.4351 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
484	SI.BRIDGE	GF	JANTX	049	.249	0	45	10A	.5	GF 80%. AI 20%
482	SI.BRIDGE	GF	JANTX	049	.497	0	45	15A	.5	GF 80%. AI 20%
483	SI.BRIDGE	GF	JANTX	049	.746	0	45	25A	.5	GF 80%. AI 20%
485	SI.BRIDGE	GF	JANTX	049	.249	0	45	25A	.5	GF 80%. AI 20%
12.	TOTAL	1.741 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
500	SI.GP	SAT	JANTX	058D	1.90	0	25		.2	
13.	TOTAL	1.9 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
213	SI.GP.RECT	AI	JANTX	045	.011298	0	55	.4A	.0666	
239	SI.GP.RECT	AI	JANTX	045	.011298	0	55	1.09A	.12	
211	SI.GP.RECT	AI	JANTX	045	.007532	0	55	3A	.55	
210	SI.GP.RECT	AI	JANTX	045	.003766	0	55	12A	.36	
231	SI.GP.RECT	AI	JANTX	045	.015064	0	55	30A	.2000	
226	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.9A		
238	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.92A	.11	
236	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.50A	.22	
217	SI.GP.RECT	AI	JANTX	045	.007532	0	55	1.50A	.095	
233	SI.GP.RECT	AI	JANTX	045	.007532	0	55	30A	.2000	
234	SI.GP.RECT	AI	JANTX	045	.007532	0	55	30A	.2000	
223	SI.GP.RECT	AI	JANTX	045	.022596	0	55	1.70A	.060	
227	SI.GP.RECT	AI	JANTX	045	.011298	0	55	12A	.4046	
224	SI.GP.RECT	AI	JANTX	045	.007532	0	55	1.57A		
235	SI.GP.RECT	AI	JANTX	045	.022596	0	55	1.60A	.55	
216	SI.GP.RECT	AI	JANTX	045	.007532	0	55	1.60A	.19	
229	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.50A	.11	
240	SI.GP.RECT	AI	JANTX	045	.011298	0	55	1.95A	.0437	
209	SI.GP.RECT	AI	JANTX	045	.003766	0	55	3A	.3625	
241	SI.GP.RECT	AI	JANTX	045	.003766	0	55	.357A	.024	
221	SI.GP.RECT	AI	JANTX	045	.015164	0	55	1.60A	.0035	
208	SI.GP.RECT	AI	JANTX	045	.003766	0	55	3A	.435	
214	SI.GP.RECT	AI	JANTX	045	.003766	0	55	20A		
220	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.60A	.3625	
207	SI.GP.RECT	AI	JANTX	045	.015064	0	55	30A	.220	
212	SI.GP.RECT	AI	JANTX	045	.003766	0	55	.4A	.0977	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10↑6	FAIL	TEMP	RATING	STRESS	COMMENTS
232	SI.GP.RECT	AI	JANTX	045	.007532	0	55	20A	.6 2	
222	SI.GP.RECT	AI	JANTX	045	.007532	0	55	1.60A	.19	
215	SI.GP.RECT	AI	JANTX	045	.003766	0	55	20A		
237	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.50A	.033	
206	SI.GP.RECT	AI	JANTX	045	.011298	0	55	12A	.502	
230	SI.GP.RECT	AI	JANTX	045	.007532	0	55	12A	.36	
218	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.58A	.079	
220	SI.GP.RECT	AI	JANTX	045	.011298	0	55	1.58A	.042	
225	SI.GP.RECT	AI	JANTX	045	.003766	0	55	1.92A		
219	SI.GP.RECT	AI	JANTX	045	.011298	0	55	1.58A	.11	
	14. TOTAL	.293848 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
133	SI.GP.RECT	AU	JANTX	056	.000493	0		3A		
132	SI.GP.RECT	AU	JANTX	056	.000237	0		35A		
	15. TOTAL	.00073 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
~~104~~	~~SI.GP.RECT~~	~~GB~~	~~JANTXV~~	~~051A~~	~~107.461~~	~~0~~	~~10~~	~~30A~~	~~.5~~	
~~103~~	~~SI.GP.RECT~~	~~GB~~	~~JANTXV~~	~~051A~~	~~17.01~~	~~0~~	~~10~~	~~240A~~	~~.5~~	
~~105~~	~~SI.GP.RECT~~	~~GB~~	~~JANTXV~~	~~051A~~	~~6931.263~~	~~0~~	~~10~~	~~2.5A~~	~~.5~~	
134	SI.GP.RECT	GB	JANTXV	057B	12.073	0	37	22A	.7	
	16. TOTAL	7068.71 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
109	SI.GP.RECT	GF	JAN	044A	114.59	11	25		.3	
415	SI.GP.RECT	GF	JAN	044A	.041	0	25			BRIDGE
414	SI.GP.RECT	GF	JAN	044A	.027	0	25			BRIDGE
155	SI.GP.RECT	GF	JAN	055B	.138	0	30	.80A		
156	SI.GP.RECT	GF	JAN	055B	43.906	1	30	1A		
152	SI.GP.RECT	GF	JAN	055B	.184	0	30	.07A		
150	SI.GP.RECT	GF	JAN	055B	31.31	1	30	12A		
159	SI.GP.RECT	GF	JAN	055B	.322	0	30	35A		
154	SI.GP.RECT	GF	JAN	055B	.046	0	30	.35A		
153	SI.GP.RECT	GF	JAN	055B	1.234	0	30	.25A		
157	SI.GP.RECT	GF	JAN	055B	1.637	0	30	1.25A		
462	SI.GP.PECT	GF	JAN	049A	12.07	2	35		.5	PWR
	17. TOTAL	205.505 MILLION HOURS				15 FAILURES			RATE IS	.729909E-1 FAIL/10**6HRS
160	SI.GP.PECT	GF	JANTX	055A	40.587	2	35	.25A		
131	SI.GP.RECT	GF	JANTX	055A	.961	0	35			
145	SI.GP.PECT	GF	JANTX	055A	.24	0	35	10A		
140	SI.GP.PECT	GF	JANTX	055A	2.902	1	35			
144	SI.GP.RECT	GF	JANTX	055A	2.302	0	35	3A		
161	SI.GP.PECT	GF	JANTX	055A	4.37	0	35	1A		
416	SI.GP.PECT	GF	JANTX	055A	7.256	0	35			BRIDGE

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
417	SI.GP.RECT	GF	JANTX	055A	.1	0	35			BRIDGE
146	SI.GP.RECT	GF	JANTX	055A	29.403	0	35	12A		
147	SI.GP.RECT	GF	JANTX	055A	8.646	2	35	35A		
141	SI.GP.RECT	GF	JANTX	055A	11.570	0	35	1A		
142	SI.GP.RECT	GF	JANTX	055A	2563.950	0	35	1.25A		
243	SI.GP.RECT	GF	JANTX	049	.994	0	45	12A	.5	GF 80%. AI 20%
242	SI.GP.RECT	GF	JANTX	049	.497	0	45	30A	.5	GF 80%. AI 20%
	18. TOTAL	2673.87 MILLION HOURS				5 FAILURES			RATE IS	.106995E-2 FAIL/10**6HRS
635	SI.GP.RECT	GF	LOWER	063	10.30	103	30		.2	PWR
634	SI.GP.RECT	GF	LOWER	063	50.36	7	30		.1	PWR
637	SI.GP.RECT	GF	LOWER	063	66.40	50	30		.1	
636	SI.GP.RECT	GF	LOWER	063	10.30	15	30		.4	PWR
181	SI.GP.RECT	GF	LOWER	053	25	13	55		.5	
412	SI.GP.RECT	GF	LOWER	053	87	121	55	10A		BRIDGE
177	SI.GP.RECT	GF	LOWER	053	1531	247	55	10A	.5	
180	SI.GP.RECT	GF	LOWER	053	21	7	55		.5	
179	SI.GP.RECT	GF	LOWER	053	106	103	55	10A	.5	
182	SI.GP.RECT	GF	LOWER	053	1	12	55	100A	.5	
413	SI.GP.RECT	GF	LOWER	053	3	7	55	30A		BRIDGE
178	SI.GP.RECT	GF	LOWER	053	29	15	55	10A	.5	
	19. TOTAL	1956.6 MILLION HOURS				700 FAILURES			RATE IS	.357763 FAIL/10**6HRS
169	SI.GP.RECT	GM	JAN	054	.020	0	30	30A	.8	
170	SI.GP.RECT	GM	JAN	054	.139	0	30	2A	.8	
166	SI.GP.RECT	GM	JAN	054	.139	0	30	12A	.8	
172	SI.GP.RECT	GM	JAN	054	.062	0	30	3A	.8	
167	SI.GP.RECT	GM	JAN	054	.44	0	30	12A	.8	
173	SI.GP.RECT	GM	JAN	054	.014	0	30	3A	.8	
168	SI.GP.RECT	GM	JAN	054	.510	0	30	30A	.8	
171	SI.GP.RECT	GM	JAN	054	.097	0	30		.8	
165	SI.GP.RECT	GM	JAN	054	.245	0	30	6A	.8	
164	SI.GP.RECT	GM	JAN	054	.042	0	30	50A	.8	
163	SI.GP.RECT	GM	JAN	054	.020	0	30	35A	.8	
	20. TOTAL	1.752 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
604	SI.GP.RECT	GM	JANTX	066	.0416	0	30	3A		
592	SI.GP.RECT	GM	JANTX	066	.9996	0	30	35A		
602	SI.GP.RECT	GM	JANTX	066	.9163	0	30	1A		
603	SI.GP.RECT	GM	JANTX	066	.2916	0	30	3A		
	21. TOTAL	2.2491 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
162	SI.GP.RECT	GM	LOWER	054	.021	0	30	20A	.8	
	22. TOTAL	.021 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
244	SI.GP.RECT	GM	MIL	054	.007	0	30		.8	
23.	TOTAL	.007	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
591	SI.GP.RECT	SAT	JANTX	058E	.053724	0	25	200A	.100	
505	SI.GP.RECT	SAT	JANTX	058E	.053725	0	25	3A	.010	
106	SI.GP.RECT	SAT	JANTX	052	45.240	0	25		.2	
525	SI.GP.RECT	SAT	JANTX	058E	.078144	0	25	20A	.144	
24.	TOTAL	45.4256	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
174	SI.GP.RECT	SUB	JAN	051B	2.369	0	35	.25A	.2	
151	SI.GP.RECT	SUB	JAN	051B	405.645	2	35	50A	.2	
150	SI.GP.RECT	SUB	JAN	051B	30.797	0	35	50A	.2	
175	SI.GP.RECT	SUB	JAN	051B	2.369	0	35	1A	.2	
176	SI.GP.RECT	SUB	JAN	051B	971.29	0	35	.25A	.2	
149	SI.GP.RECT	SUB	JAN	051B	127.926	0	35	35A	.2	
25.	TOTAL	1620.4	MILLION HOURS			2	FAILURES		RATE IS	.123427E-2 FAIL/10**6HRS
188	SI.GP.RECT	SUB	MIL	014	1.5	0				
26.	TOTAL	1.5	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
68	SI.GP.RECT.FAST REC	GF	JANTX	051C	.032	0	25	30A	.2	FAST RECOV RECT
70	SI.GP.RECT.FAST REC	GF	JANTX	051C	.223	0	25	12A	.2	FAST RECOV RECT
27.	TOTAL	.255	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
67	SI.GP.RECT.FAST REC	NS	JANTX	051C	.013	0	35	30A	.2	FAST RECOV RECT
69	SI.GP.RECT.FAST REC	NS	JANTX	051C	.092	0	35	12A	.2	FAST RECOV RECT
28.	TOTAL	.105	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
581	SI.GP.RECT.FAST REC	SAT	JANTX	058E	.092988	0	25	2A	.100	
510	SI.GP.RECT.FAST REC	SAT	JANTX	058E	1.36752	0	25	2A	.100	
535	SI.GP.RECT.FAST REC	SAT	JANTX	058E	.019536	0	25	2A	.100	
575	SI.GP.RECT.FAST REC	SAT	JANTX	058E	.019536	0	25	2A	.100	
524	SI.GP.RECT.FAST REC	SAT	JANTX	058E	.04884	0	25	2A	.105	
29.	TOTAL	1.54842	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
100	SI.GP.SIG	AI		045	.003766	0	55	.4A		
109	SI.GP.SIG	AI		045	.003766	0	55	.4A		
30.	TOTAL	.007532	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
124	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.153A	0	
98	SI.GP.SIG	AI	JANTX	045	.03766	0	55	.126A	.004	
117	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.00033A	.293	
110	SI.GP.SIG	AI	JANTX	045	.007532	0	55	.4A		
119	SI.GP.SIG	AI	JANTX	045	.003766	0	55		.017	
100	SI.GP.SIG	AI	JANTX	045	.007532	0	55	.126A	.2	
104	SI.GP.SIG	AI	JANTX	045	.060256	0	55	.060A	.215	
129	SI.GP.SIG	AI	JANTX	045	.007532	0	55	.070A		
105	SI.GP.SIG	AI	JANTX	045	0.003766	0	55	.151A	.01	
102	SI.GP.SIG	AI	JANTX	045	.007532	0	55	.126A	.23	
103	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.126A	.062	
127	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.357A	.072	
107	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.151A	0	
111	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.15A		
115	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.00065A	.023	
128	SI.GP.SIG	AI	JANTX	045	.007532	0	55	1.95A	.0035	
99	SI.GP.SIG	AI	JANTX	045	.007532	0	55	.126A	0	
106	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.151A	0	
123	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.01A	.232	
118	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.00033A	.419	
116	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.00033A	.004	
112	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.15A		
125	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.144A	.232	
122	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.01A	0	
130	SI.GP.SIG	AI	JANTX	045	.003766	0	55		.0222	
126	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.153A	.23	
121	SI.GP.SIG	AI	JANTX	045	.003766	0	55	1.4A	.033	
101	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.126A	0	
113	SI.GP.SIG	AI	JANTX	045	.060256	0	55	.06A	.215	
114	SI.GP.SIG	AI	JANTX	045	.003766	0	55	.00065A	0	
120	SI.GP.SIG	AI	JANTX	045	.007532	0	55		.5526	
31.	TOTAL				.289982 MILLION HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
10	SI.GP.SIG	AU	JANTX	056	.000158	0		.2A		
13	SI.GP.SIG	AU	JANTX	056	.001875	0		.1A		
12	SI.GP.SIG	AU	JANTX	056	.0333	0		.01A		
14	SI.GP.SIG	AU	JANTX	056	.000296	0		.4A		
11	SI.GP.SIG	AU	JANTX	056	.002151	0		.75A		
32.	TOTAL				.03778 MILLION HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
195	SI.GP.SIG	GB	JANTXV	051A	2973.1	0	10	.2A	.5	SIG
97	SI.GP.SIG	GB	JANTXV	057B	27.922	0	37	.25A	.7	
33.	TOTAL				3001.02 MILLION HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
197	SI.GP.SIG	GF	JAN	044A	1452.89	5	25		.3	SIG
423	SI.GP.SIG	GF	JAN	044A	1.237	0	25		.3	
422	SI.GP.SIG	GF	JAN	044A	.645	0	25		.3	
199	SI.GP.SIG	GF	JAN	044A	6087.72	33	25		.3	
198	SI.GP.SIG	GF	JAN	044A	1300.023	19	25		.3	SIG
21	SI.GP.SIG	GF	JAN	055B	321.065	5	30			
20	SI.GP.SIG	GF	JAN	055B	12.705	0	30	.2A		
22	SI.GP.SIG	GF	JAN	055B	193.297	0	30	.0001A		
26	SI.GP.SIG	GF	JAN	055B	11.601	0	30	.05A		
23	SI.GP.SIG	GF	JAN	055B	150.403	0	30	.0003A		
27	SI.GP.SIG	GF	JAN	055B	145.103	7	30	.1A		
25	SI.GP.SIG	GF	JAN	055B	1450.932	10	30	.01A		
24	SI.GP.SIG	GF	JAN	055B	.921	0	30	.004A		
1	SI.GP.SIG	GF	JAN	055B	20.834	3	30	.400A		
34.	TOTAL	11246.2 MILLION HOURS				90	FAILURES		RATE IS	.800272E-2 FAIL/10**6HRS
80	SI.GP.SIG	GF	JANTX	051C	.220	0	25		.2	
76	SI.GP.SIG	GF	JANTX	051C	.1	0	25		.2	
78	SI.GP.SIG	GF	JANTX	051C	.62	0	25		.2	
82	SI.GP.SIG	GF	JANTX	051C	1.300	0	25		.2	
74	SI.GP.SIG	GF	JANTX	051C	.445	0	25	50A	.2	
201	SI.GP.SIG	GF	JANTX	051C	.670	0	25	.01A	.2	
203	SI.GP.SIG	GF	JANTX	051C	2.085	0	25	.01A	.2	
205	SI.GP.SIG	GF	JANTX	051C	.440	0	25	3A	.2	
192	SI.GP.SIG	GF	JANTX	051C	.046	0	25	.02A	.2	
410	SI.GP.SIG	GF	JANTX	055A	.133	0	35			QUAD
424	SI.GP.SIG	GF	JANTX	055A	2.052	0	35		.3	
2	SI.GP.SIG	GF	JANTX	055A	.267	0	35			
9	SI.GP.SIG	GF	JANTX	055A	49.117	0	35	.020A		
6	SI.GP.SIG	GF	JANTX	055A	1.034	0	35	.0001A		
8	SI.GP.SIG	GF	JANTX	055A	287.030	0	35	.010A		
7	SI.GP.SIG	GF	JANTX	055A	1.960	0	35			
4	SI.GP.SIG	GF	JANTX	055A	542.344	0	35	.200A		
5	SI.GP.SIG	GF	JANTX	055A	272.939	14	35	.400A		
411	SI.GP.SIG	GF	JANTX	055A	.133	4	35			QUAD
3	SI.GP.SIG	GF	JANTX	055A	84.756	2	35	.100A		
409	SI.GP.SIG	GF	JANTX	055A	.067	0	35			QUAD
425	SI.GP.SIG	GF	JANTX	055A	55.72	1	35		.3	
35.	TOTAL	1305.21 MILLION HOURS				21	FAILURES		RATE IS	.160894E-1 FAIL/10**6HRS
627	SI.GP.SIG	GF	JANTXV	068	.356390	0	30		<.3	
628	SI.GP.SIG	GF	JANTXV	068	1.211726	0	30		<.3	
36.	TOTAL	1.56812 MILLION HOURS				0	FAILURES		RATE IS	0 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
632	SI.GP.SIG	GF	LOWER	063	120	15	30		.1	
633	SI.GP.SIG	GF	LOWER	063	10.4	2	30		.2	
194	SI.GP.SIG	GF	LOWER	053	108	17	55		.5	SIG.STABISTOR
193	SI.GP.SIG	GF	LOWER	053	5429	601	55	1A	.5	SIG
37.	TOTAL	5667.4 MILLION HOURS				635 FAILURES			RATE IS	.112044 FAIL/10**6HRS
32	SI.GP.SIG	GM	JAN	054	.670	0	30	.2A	.8	
610	SI.GP.SIG	GM	JAN	066	.2916	0	30	750MA		
31	SI.GP.SIG	GM	JAN	054	.111	0	30	.75A	.8	
29	SI.GP.SIG	GM	JAN	054	.333	0	30	.1A	.8	
30	SI.GP.SIG	GM	JAN	054	30.212	0	30	.2A	.8	
36	SI.GP.SIG	GM	JAN	054	.312	0	30	.01A	.8	
35	SI.GP.SIG	GM	JAN	054	.097	0	30	.4A	.8	
34	SI.GP.SIG	GM	JAN	054	.416	0	30	3A	.8	
33	SI.GP.SIG	GM	JAN	054	.028	0	30	.01A	.8	
38.	TOTAL	32.4786 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
601	SI.GP.SIG	GM	JANTX	066	.2499	0	30	10MA		
600	SI.GP.SIG	GM	JANTX	066	.1249	0	30	10MA		
599	SI.GP.SIG	GM	JANTX	066	5.2060	2	30	10MA		
606	SI.GP.SIG	GM	JANTX	066	.1666	0	30	400MA		
39.	TOTAL	5.7474 MILLION HOURS				2 FAILURES			RATE IS	.347983 FAIL/10**6HRS
449	SI.GP.SIG	NS	JAN	032AG	15.840	0	40			
40.	TOTAL	15.84 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
202	SI.GP.SIG	NS	JANTX	051C	1.175	0	35	.01A	.2	
79	SI.GP.SIG	NS	JANTX	051C	.105	0	35		.2	
200	SI.GP.SIG	NS	JANTX	051C	.311	0	35	.01A	.2	
191	SI.GP.SIG	NS	JANTX	051C	.02	0	35	.02A	.2	
204	SI.GP.SIG	NS	JANTX	051C	.183	0	35	3A	.2	
81	SI.GP.SIG	NS	JANTX	051C	.556	0	35		.2	
75	SI.GP.SIG	NS	JANTX	051C	.046	0	35		.2	
77	SI.GP.SIG	NS	JANTX	051C	.255	0	35		.2	
73	SI.GP.SIG	NS	JANTX	051C	.183	0	35	50A	.2	
41.	TOTAL	2.834 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
506	SI.GP.SIG	SAT	JANTX	058A	50.693	0	25	400MA	.2	
522	SI.GP.SIG	SAT	JANTX	058E	.303616	0	25	200MA	.004	
491	SI.GP.SIG	SAT	JANTX	058B	.0440	0	25		.3	
507	SI.GP.SIG	SAT	JANTX	058A	14.194	0	25	10MA	.2	
495	SI.GP.SIG	SAT	JANTX	058C	36.71	0	25		.2	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
508	SI.GP.SIG	SAT	JANTX	058A	10.814	0	25	200MA	.2	
497	SI.GP.SIG	SAT	JANTX	058A	26.240	0	25		.4	
494	SI.GP.SIG	SAT	JANTX	058B	.470	0	25		.2	
502	SI.GP.SIG	SAT	JANTX	058D	.0492	0	25		.4	
509	SI.GP.SIG	SAT	JANTX	058E	.037592	0	25		.025	
539	SI.GP.SIG	SAT	JANTX	058E	.04744	0	25	3AMA	.036	
401	SI.GP.SIG	SAT	JANTX	052	.36	0	25			HI-VOLT
523	SI.GP.SIG	SAT	JANTX	058E	.33200	0	25	400MA	.051	
196	SI.GP.SIG	SAT	JANTX	052	269.82	0	25		.2	SIG
543	SI.GP.SIG	SAT	JANTX	058E	.028464	0	25	400MA	.077	
548	SI.GP.SIG	SAT	JANTX	058E	.009488	0	25	200MA	.100	
555	SI.GP.SIG	SAT	JANTX	058E	.018976	0	25	400MA	.050	
42.	TOTAL	410.173	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
41	SI.GP.SIG	SUB	JAN	051B	14.214	0	35	.005A	.2	
15	SI.GP.SIG	SUB	JAN	051B	650.582	0	35	.1A	.2	
16	SI.GP.SIG	SUB	JAN	051B	35.535	0	35	.75A	.2	
37	SI.GP.SIG	SUB	JAN	051B	90.022	0	35	.005A	.2	
19	SI.GP.SIG	SUB	JAN	051B	7.107	0	35	.02A	.2	
40	SI.GP.SIG	SUB	JAN	051B	5849.061	19	35	.1A	.2	
17	SI.GP.SIG	SUB	JAN	051B	184.782	0	35	.2A	.2	
33	SI.GP.SIG	SUB	JAN	051B	1686.720	3	35	.01A	.2	
18	SI.GP.SIG	SUB	JAN	051B	56.856	0	35	3A	.2	
42	SI.GP.SIG	SUB	JAN	051B	2800.150	0	35	.4A	.2	
34	SI.GP.SIG	SUB	JAN	051B	459.586	2	35	.002A	.2	
43.	TOTAL	11042.6	MILLION HOURS			32	FAILURES		RATE IS	.27021E-2 FAIL/10**6HRS
20	SI.GP.SIG	SUB	LOWER	051B	4.738	0	35	.4A	.2	
44.	TOTAL	4.738	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HPS
71	SI.GP.SIG	SUB	MIL	014	7104.322	14	40	1W		
72	SI.GP.SIG	SUB	MIL	014	196.9268	0	45	1W		
45.	TOTAL	7301.25	MILLION HOURS			14	FAILURES		RATE IS	.191749E-2 FAIL/10**6HPS
467	SI.GP.SW	GF	JAN	049A	95.031	1	35		.5	
457	SI.GP.SW	GF	JAN	049A	9.571	0	35		.5	MED PWR
456	SI.GP.SW	GF	JAN	049A	1452.377	4	35		.5	
454	SI.GP.SW	GF	JAN	049A	1422.947		35		.5	
138	SI.GP.SW	GF	JAN	049A	152.124	0	35		.5	
46.	TOTAL	3132.05	MILLION HOURS			5	FAILURES		RATE IS	.15964E-2 FAIL/10**6HPS
631	SI.GP.SW	GF	JANTX	068	.855366	0	30		<.3	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
400	SI.GP.SW	GF	JANTX	055A	9.207	0	35			
89	SI.GP.SW	GF	JANTX	049	23.62	0	45	.75A	.5	GF 80%, AI 20%
88	SI.GP.SW	GF	JANTX	049	130.722	1	45	.02A	.5	GF 80%, AI 20%
87	SI.GP.SW	GF	JANTX	049	2293.39	3	45	.2A	.5	GF 80%, AI 20%
90	SI.GP.SW	GF	JANTX	049	6.96	0	45	3A	.5	GF 80%, AI 20%
47.	TOTAL				2472.75 MILLION HOURS	4 FAILURES			RATE IS	.161763E-2 FAIL/10**6HRS
619	SI.GP.SW	GM	JAN	066	.4998	0	30			
48.	TOTAL				.4998 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
605	SI.GP.SW	GM	JANTX	066	1.4162	0	30			
49.	TOTAL				1.4162 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
538	SI.GP.SW	SAT	JANTX	058E	.004744	0	25	400MA	.100	
551	SI.GP.SW	SAT	JANTX	058E	.208736	0	25	10MA	.100	
529	SI.GP.SW	SAT	JANTX	058E	1.05965	0	25	100MA	.098	
497	SI.GP.SW	SAT	JANTX	058C	2.962	0	25		.4	
510	SI.GP.SW	SAT	JANTX	058E	.313104	0	25	10MA	.100	
559	SI.GP.SW	SAT	JANTX	058E	.303616	0	25	10MA	.038	
569	SI.GP.SW	SAT	JANTX	058E	.14232	0	25	100MA	.070	
588	SI.GP.SW	SAT	JANTX	058E	.289384	0	25	10MA	.100	
517	SI.GP.SW	SAT	JANTX	058E	1.43269	0	25	100MA	.094	
582	SI.GP.SW	SAT	JANTX	058E	.493376	0	25	10MA	.010	
520	SI.GP.SW	SAT	JANTX	058E	.037952	0	25	50MA	.100	
576	SI.GP.SW	SAT	JANTX	058E	.085392	0	25	200MA	.100	
577	SI.GP.SW	SAT	JANTX	058E	.123344	0	25	200MA	.100	
519	SI.GP.SW	SAT	JANTX	058E	.37952	0	25	400MA	.015	
531	SI.GP.SW	SAT	JANTX	058E	.161296	0	25	10MA	.100	
549	SI.GP.SW	SAT	JANTX	058E	.028464	0	25	3AMA	.004	
567	SI.GP.SW	SAT	JANTX	058E	.645184	0	25	100MA	.061	
570	SI.GP.SW	SAT	JANTX	058E	.075904	0	25	10MA	.100	
560	SI.GP.SW	SAT	JANTX	058E	.161296	0	25	10MA	.100	
516	SI.GP.SW	SAT	JANTX	058E	.208736	0	25	200MA	.050	
568	SI.GP.SW	SAT	JANTX	058E	.170784	0	25	200MA	.100	
545	SI.GP.SW	SAT	JANTX	058E	.085392	0	25	10MA	.100	
530	SI.GP.SW	SAT	JANTX	058E	.62621	0	25	10MA	.100	
50.	TOTAL				10.7991 MILLION HOURS	0 FAILURES			RATE IS	0 FAIL/10**6HRS
460	SI.RECT	GF	JAN	049A	36.212	1	35		.5	
471	SI.RECT	GF	JAN	049A	9.599	0	35		.5	
473	SI.RECT	GF	JAN	049A	5.759	0	35		.5	AVALANCH
477	SI.RECT	GF	JAN	049A	23.997	0	35		.5	
475	SI.RECT	GF	JAN	049A	5.759	0	35		.5	AVALANCH
51.	TOTAL				81.326 MILLION HOURS	1 FAILURES			RATE IS	.122962E-1 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SPCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
486	SI.RECT	GF	JANTX	049	1.989	1	45		.5	GF 80%, AI 20%
	52. TOTAL			1.989 MILLION HOURS		1 FAILURES			RATE IS	.502765 FAIL/10**6HRS
140	SI.RECT.STACK	GF	JANTX	055A	.240	0	35		.7	
139	SI.RECT.STACK	GF	JANTX	055A	.4	1	35		.7	
143	SI.RECT.STACK	GF	JANTX	055A	.033	0	35		.7	
	53. TOTAL			.673 MILLION HOURS		1 FAILURES			RATE IS	1.48588 FAIL/10**6HRS
367	SI.ZEN	AI		045	.003766	0	55		.3	
	54. TOTAL			.003766 MILLION HOURS		0 FAILURES			RATE IS	0 FAIL/10**6HRS
351	SI.ZEN	AI	JANTX	045	.003766	0	55	.4A	.3	
388	SI.ZEN	AI	JANTX	045	.003766	0	55	.101A	.3	
374	SI.ZEN	AI	JANTX	045	.003766	0	55	.017A	.3	
355	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
358	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
359	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
392	SI.ZEN	AI	JANTX	045	.003766	0	55	.049A	.3	
387	SI.ZEN	AI	JANTX	045	.003766	0	55	.1267A	.3	
371	SI.ZEN	AI	JANTX	045	.007532	0	55	.07A	.3	
378	SI.ZEN	AI	JANTX	045	.003766	0	55	.26A	.3	
390	SI.ZEN	AI	JANTX	045	.007532	0	55		.3	
369	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
376	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
349	SI.ZEN	AI	JANTX	045	.003766	0	55	.4A	.3	
373	SI.ZEN	AI	JANTX	045	.003766	0	55	.04A	.3	
375	SI.ZEN	AI	JANTX	045	.003766	0	55	37.2A	.3	
364	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
354	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
370	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
389	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
362	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
366	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
365	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
360	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
384	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
353	SI.ZEN	AI	JANTX	045	.007532	0	55		.3	
383	SI.ZEN	AI	JANTX	045	.003766	0	55	.049A	.3	
372	SI.ZEN	AI	JANTX	045	.003766	0	55	.178A	.3	
361	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
356	SI.ZEN	AI	JANTX	045	.007532	0	55		.3	
352	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
363	SI.ZEN	AI	JANTX	045	.003766	0	55	.178A	.3	
386	SI.ZEN	AI	JANTX	045	.003766	0	55	.06831A	.3	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SPCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
350	SI.ZEN	AI	JANTX	045	.003766	0	55	.4A	.3	
385	SI.ZEN	AI	JANTX	045	.007532	0	55		.3	
379	SI.ZEN	AI	JANTX	045	.003766	0	55	60A	.3	
377	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
381	SI.ZEN	AI	JANTX	045	.007532	0	55	.049A	.3	
357	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
358	SI.ZEN	AI	JANTX	045	.003766	0	55		.3	
390	SI.ZEN	AI	JANTX	045	.007532	0	55	62.6A	.3	
	55. TOTAL	180768 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
249	SI.ZEN	AU	JANTX	056	.000196	0	45		.4	
266	SI.ZEN	AU	JANTX	056	.000296	0	45		.4	
267	SI.ZEN	AU	JANTX	056	.004292	0	45		.4	
247	SI.ZEN	AU	JANTX	056	.000316	0	45		.4	
295	SI.ZEN	AU	JANTX	056	.001184	0	45		.4	
[illegible]	SI.ZEN	AU	JANTX	056	.006749	0	45		.4	
348	SI.ZEN	AU	JANTX	056	.000148	0	50		.4	
	56. TOTAL	.013181 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
[illegible]	SI.ZEN	GB	JANTXV	051A	36089.13	4	10	.004A	.5	
[illegible]	SI.ZEN	GB	JANTXV	051A	1253.717	1	10		.5	
329	SI.ZEN	GB	JANTXV	051A	1450.729	1	10			
291	SI.ZEN	GB	JANTXV	051A	1199.986	1	10	.021A	.5	
290	SI.ZEN	GB	JANTXV	051A	411.936	0	10	.028A	.5	
252	SI.ZEN	GB	JANTXV	057B	.755	0	37		.7	
253	SI.ZEN	GB	JANTXV	057B	.755	0	37		.7	
250	SI.ZEN	GB	JANTXV	057B	1.508	0	37		.7	
251	SI.ZEN	GB	JANTXV	057B	.755	0	37		.7	
	57. TOTAL	40409.3 MILLION HOURS				7 FAILURES			RATE IS	.173228E-3 FAIL/10**6HRS
294	SI.ZEN	GF	JAN	044A	55.175	10	25		.5	
330	SI.ZEN	GF	JAN	044A	22.582	1	25			
258	SI.ZEN	GF	JAN	055B	12.718	4	30		.3	
259	SI.ZEN	GF	JAN	055B	2.210	0	30		.3	
260	SI.ZEN	GF	JAN	055B	4.603	0	30		.3	
346	SI.ZEN	GF	JAN	055B	3.351	0	30			
257	SI.ZEN	GF	JAN	055B	210.981	10	30		.3	
455	SI.ZEN	GF	JAN	049A	15.080	0	35		.5	
472	SI.ZEN	GF	JAN	049A	.959	0	35		.5	
450	SI.ZEN	GF	JAN	049A	4.602	0	35		.5	
469	SI.ZEN	GF	JAN	049A	13.430	0	35		.5	
480	SI.ZEN	GF	JAN	049A	3.017	1	35		.5	
463	SI.ZEN	GF	JAN	049A	4.602	1	35		.5	
470	SI.ZEN	GF	JAN	049A	5.739	1	35		.5	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP RATING		STRESS	COMMENTS
459	SI.ZEN	GF	JAN	049A	33.234	0	35		.5	
460	SI.ZEN	GF	JAN	049A	19.190	1	35		.5	
479	SI.ZEN	GF	JAN	049A	6.035	0	35		.5	
461	SI.ZEN	GF	JAN	049A	4.602	0	35		.5	
453	SI.ZEN	GF	JAN	049A	185.972	3	35		.5	
58.	TOTAL	608.106	MILLION HOURS			40	FAILURES		RATE IS	.065778 FAIL/10**6HRS
332	SI.ZEN	GF	JANTX	051C	.046	0	25		.2	
307	SI.ZEN	GF	JANTX	051C	2.310	0	25		.3	
309	SI.ZEN	GF	JANTX	051C	.064	0	25		.3	
330	SI.ZEN	GF	JANTX	051C	.023	0	25		.2	
334	SI.ZEN	GF	JANTX	051C	.133	0	25		.2	
261	SI.ZEN	GF	JANTX	055A	2.425	0	35		.3	
262	SI.ZEN	GF	JANTX	055A	65.251	2	35		.3	
264	SI.ZEN	GF	JANTX	055A	14.141	1	35		.3	
347	SI.ZEN	GF	JANTX	055A	21.505	0	35			
265	SI.ZEN	GF	JANTX	055A	6.404	1	35		.3	
263	SI.ZEN	GF	JANTX	055A	21.662	0	35		.3	
326	SI.ZEN	GF	JANTX	049	.746	0	45		.5	GF 80%. AI 20%
325	SI.ZEN	GF	JANTX	049	1.49	0	45		.5	GF 80%. AI 20%
336	SI.ZEN	GF	JANTX	049	1.49	1	45		.5	GF 80%. AI 20%
324	SI.ZEN	GF	JANTX	049	8.7	0	45		.5	GF 80%. AI 20%
327	SI.ZEN	GF	JANTX	049	2.98	0	45		.5	GF 80%. AI 20%
335	SI.ZEN	GF	JANTX	049	.746	0	45		.5	GF 80%. AI 20%
59.	TOTAL	150.284	MILLION HOURS			5	FAILURES		RATE IS	.332703E-1 FAIL/10**6HRS
625	SI.ZEN	GF	JANTXV	068	.142556	0	30		<.3	
630	SI.ZEN	GF	JANTXV	068	.213834	0	30		<.3	
626	SI.ZEN	GF	JANTXV	068	.142556	0	30		<.3	
629	SI.ZEN	GF	JANTXV	068	.071278	0	30		<.3	
60.	TOTAL	.570224	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
638	SI.ZEN	GF	LOWER	063	77.16	99	30		.1	
639	SI.ZEN	GF	LOWER	063	1.43	0	30		.2	
287	SI.ZEN	GF	LOWER	053	36	31	55	.01A	.5	
284	SI.ZEN	GF	LOWER	053	77	40	55	.004A	.5	
288	SI.ZEN	GF	LOWER	053	161	174	55			
290	SI.ZEN	GF	LOWER	053	10	10	55		.5	
285	SI.ZEN	GF	LOWER	053	41	13	55	.1A	.5	
283	SI.ZEN	GF	LOWER	053	206	80	55	.0137A	.5	
286	SI.ZEN	GF	LOWER	053	89	72	55	.0344A	.5	
282	SI.ZEN	GF	LOWER	053	687	203	55	.04A	.5	
61.	TOTAL	1465.59	MILLION HOURS			730	FAILURES		RATE IS	.498093 FAIL/10**6HRS

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STPESS	COMMENTS
269	SI.ZEN	GM	JAN	054	.014	0	30		.8	
339	SI.ZEN	GM	JAN	054	.722	0	30		.8	
270	SI.ZEN	GM	JAN	054	.134	0	30		.8	
272	SI.ZEN	GM	JAN	054	.264	1	30		.8	
275	SI.ZEN	GM	JAN	054	.745	0	30		.8	
617	SI.ZEN	GM	JAN	066	.0416	0	30	1W	.7	
273	SI.ZEN	GM	JAN	054	.069	0	30		.8	
274	SI.ZEN	GM	JAN	054	4.03	3	30		.8	
620	SI.ZEN	GM	JAN	066	.0416	0	30	400MW	.7	
268	SI.ZEN	GM	JAN	054	.014	0	30		.8	
271	SI.ZEN	GM	JAN	054	.042	0	30		.8	
62. TOTAL		6.9172 MILLION HOURS				4 FAILURES			RATE IS	.578269 FAIL/10**6HRS
607	SI.ZEN	GM	JANTX	066	.0416	0	30	400MW	.5	
596	SI.ZEN	GM	JANTX	066	.0416	0	30	1W	.5	
595	SI.ZEN	GM	JANTX	066	.1666	0	30	1W	.5	
614	SI.ZEN	GM	JANTX	066	.0416	0	30	400MW	.5	
593	SI.ZEN	GM	JANTX	066	.1249	0	30	10W	.5	
608	SI.ZEN	GM	JANTX	066	.4582	0	30	400MW	.5	
611	SI.ZEN	GM	JANTX	066	.9163	0	30	400MW	.5	
612	SI.ZEN	GM	JANTX	066	.0416	0	30	400MW	.5	
598	SI.ZEN	GM	JANTX	066	.0833	0	30	1W	.5	
594	SI.ZEN	GM	JANTX	066	.1666	0	30	1W	.5	
615	SI.ZEN	GM	JANTX	066	.0416	0	30	400MW	.5	
610	SI.ZEN	GM	JANTX	066	.2916	0	30	400MW	.5	
597	SI.ZEN	GM	JANTX	066	.1666	0	30	1W	.5	
609	SI.ZEN	GM	JANTX	066	.0416	0	30	400MW	.5	
613	SI.ZEN	GM	JANTX	066	.0416	0	30			
63. TOTAL		2.6653 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
451	SI.ZEN	NS	JAN	032AG	3.557	0	40		.4	
64. TOTAL		3.557 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
331	SI.ZEN	NS	JANTX	051C	.02	0	35		.2	
306	SI.ZEN	NS	JANTX	051C	.942	0	35		.3	
308	SI.ZEN	NS	JANTX	051C	.026	0	35		.3	
333	SI.ZEN	NS	JANTX	051C	.056	0	35		.2	
337	SI.ZEN	NS	JANTX	051C	.01	0	35		.2	
65. TOTAL		1.054 MILLION HOURS				0 FAILURES			RATE IS	0 FAIL/10**6HRS
550	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
571	SI.ZEN	SAT	JANTX	058E	.030996	0	25		.3	
520	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
521	SI.ZEN	SAT	JANTX	058E	.05166	0	25	400MW	.25	
293	SI.ZEN	SAT	JANTX	052	20.9	0	25		.25	
590	SI.ZEN	SAT	JANTX	058E	.015490	0	25	400MW	.25	
513	SI.ZEN	SAT	JANTX	058E	.041320	0	25	400MW	.25	
506	SI.ZEN	SAT	JANTX	058E	.005166	0	25	400MW	.25	
527	SI.ZEN	SAT	JANTX	058E	.02503	0	25	400MW	.25	
532	SI.ZEN	SAT	JANTX	058E	.061992	0	25		.3	
559	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
533	SI.ZEN	SAT	JANTX	058E	.020664	0	25	400MW	.25	
509	SI.ZEN	SAT	JANTX	058E	.020664	0	25		.3	
507	SI.ZEN	SAT	JANTX	058E	.030996	0	25	400MW	.25	
536	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
562	SI.ZEN	SAT	JANTX	058E	.030996	0	25	400MW	.25	
500	SI.ZEN	SAT	JANTX	058E	.005166	0	25		.3	
503	SI.ZEN	SAT	JANTX	058E	.005166	0	25	400MW	.25	
573	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
572	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
565	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
504	SI.ZEN	SAT	JANTX	058E	.005166	0	25	1W	.25	
563	SI.ZEN	SAT	JANTX	058E	.020664	0	25	400MW	.25	
542	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
490	SI.ZEN	SAT	JANTX	058B	.201	0	25		.25	
557	SI.ZEN	SAT	JANTX	058E	.020664	0	25	400MW	.25	
553	SI.ZEN	SAT	JANTX	058E	.020664	0	25	400MW	.25	
496	SI.ZEN	SAT	JANTX	058C	6.04	0	25		.25	
546	SI.ZEN	SAT	JANTX	058E	.030996	0	25		.3	
505	SI.ZEN	SAT	JANTX	058A	14.346	0	25		.3	
547	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
503	SI.ZEN	SAT	JANTX	058D	.392	0	25		.25	
504	SI.ZEN	SAT	JANTX	058A	15.143	0	25		.25	
566	SI.ZEN	SAT	JANTX	058E	.010332	0	25		.3	
544	SI.ZEN	SAT	JANTX	058E	.030996	0	25	1W	.25	
526	SI.ZEN	SAT	JANTX	058E	.005166	0	25		.3	
552	SI.ZEN	SAT	JANTX	058E	.200736	0	25		.3	
511	SI.ZEN	SAT	JANTX	058E	.123984	0	25		.3	
540	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
541	SI.ZEN	SAT	JANTX	058E	.010332	0	25	400MW	.25	
556	SI.ZEN	SAT	JANTX	058E	.061992	0	25	400MW	.25	
561	SI.ZEN	SAT	JANTX	058E	.061992	0	25		.3	
554	SI.ZEN	SAT	JANTX	058E	.02503	0	25	400MW	.25	
514	SI.ZEN	SAT	JANTX	058E	.041320	0	25	400MW	.25	
512	SI.ZEN	SAT	JANTX	058E	.005166	0	25	400MW	.25	
537	SI.ZEN	SAT	JANTX	058E	.005166	0	25	400MW	.25	

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66. TOTAL 58.1606 MILLION HOURS 0 FAILURES RATE IS 0 FAIL/10**6HRS

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279	SI.ZEN	SUB	JAN	051B	66.332	0	35		.2	

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10^6	FAIL	TEMP	RATING	STRESS	COMMENTS
341	SI.ZEN	SUB	JAN	051B	2.369	0	35		.2	
342	SI.ZEN	SUB	JAN	051B	18.952	1	35		.2	
343	SI.ZEN	SUB	JAN	051B	2.369	0	35		.2	
281	SI.ZEN	SUB	JAN	051B	139.771	0	35		.2	
340	SI.ZEN	SUB	JAN	051B	23.69	0	35		.2	
276	SI.ZEN	SUB	JAN	051B	2305.037	26	35		.2	
280	SI.ZEN	SUB	JAN	051B	11.845	0	35		.2	
278	SI.ZEN	SUB	JAN	051B	90.022	2	35		.2	
277	SI.ZEN	SUB	JAN	051B	2.369	0	35		.2	
344	SI.ZEN	SUB	JAN	051D	18.952	0	35		.2	
	67. TOTAL	2681.71	MILLION HOURS			29	FAILURES		RATE IS	.010814 FAIL/10**6HRS
254	SI.ZEN	SUB	LOWER	051B	7.107	0	35		.2	
255	SI.ZEN	SUB	LOWER	051B	2.369	0	35		.2	
256	SI.ZEN	SUB	LOWER	051B	14.214	0	35		.2	
345	SI.ZEN	SUB	LOWER	051B	7.107	0	35		.2	
	68. TOTAL	30.797	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
323	SI.ZEN	SUB	MIL	014	592.923	1	40			
	69. TOTAL	592.923	MILLION HOURS			1	FAILURES		RATE IS	.168656E-2 FAIL/10**6HRS
465	SI.ZEN.REG	GF	JANTX	049	2.983	1	45		.5	GF 80%. AI 20%
	70. TOTAL	2.983	MILLION HOURS			1	FAILURES		RATE IS	.335233 FAIL/10**6HRS
440	THYR	GB	JANTXV	057B	4.527	0	37		.7	
	71. TOTAL	4.527	MILLION HOURS			0	FAILURES		RATE IS	0 FAIL/10**6HRS
438	THYR	GF	JAN	044A	24.577	1	25			
187	THYR	GF	JAN	044A	4.416	0	25		3	
198	THYR	GF	JAN	055B	112.285	11	30			
	72. TOTAL	141.278	MILLION HOURS			12	FAILURES		RATE IS	.849389E-1 FAIL/10**6HRS
136	THYR	GF	JANTX	055A	4.466	0	35	.0002A		
138	THYR	GF	JANTX	055A	1.441	13	35	.04A		SCR
439	THYR	GF	JANTX	055A	.72	0	35			
137	THYR	GF	JANTX	055A	15.61	6	35	.015A		
448	THYR	GF	JANTX	055A	2.412	0	35	.000001A		
	73. TOTAL	24.649	MILLION HOURS			19	FAILURES		RATE IS	.770822 FAIL/10**6HRS
446	THYR	GF	LOWER	053	6	30	55	15A		

ENTRY	PART DESCRIPTION	ENV	QUALITY	SRCE	HRS*10*6	FAIL	TEMP	RATING	STRESS	COMMENTS
447	THYR	GF	LOWER	053	2	11	55	15A		
441	THYR	GF	LOWER	053	41	32	55	15A		
443	THYR	GF	LOWER	053	8	36	55	15A		
	74. TOTAL		57	MILLION	HOURS	109	FAILURES		RATE IS	1.91228 FAIL/10**6HRS
445	THYR	GF	PLASTIC	053	5	4	55	15A		
442	THYR	GF	PLASTIC	053	21	23	55	15A		
	75. TOTAL		26	MILLION	HOURS	27	FAILURES		RATE IS	1.03846 FAIL/10**6HRS
444	THYR	GM	JAN	054	.035	0	30	.04A	.8	
	76. TOTAL		.035	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
623	THYR	GM	LOWER	066	.0200	0	30	1.6A.100V		
624	THYR	GM	LOWER	066	.0312	0	30	25A.600V		
	77. TOTAL		.052	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
452	THYR	NS	LOWER	032AG	.181	0	40			
	78. TOTAL		.181	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
622	TUN	GF	JAN	055B	3.406	1	30			
	79. TOTAL		3.406	MILLION	HOURS	1	FAILURES		RATE IS	.2936 FAIL/10**6HRS
400	TUN	SAT	JANTX	058A	1.312	0	25			
578	TUN	SAT	JANTX	058E	.116649	0	25		.100	
579	TUN	SAT	JANTX	058E	.116649	0	25		.100	
	80. TOTAL		1.5453	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
434	VAR	GF	JAN	044A	1.718	0	25			VARACTOR
	81. TOTAL		1.718	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS
489	VAR	SAT	JANTX	058A	19.710	0	25			
493	VAR	SAT	JANTX	058B	.0336	0	25			
498	VAR	SAT	JANTX	058C	.282	0	25			
	82. TOTAL		20.9256	MILLION	HOURS	0	FAILURES		RATE IS	0 FAIL/10**6HRS

APPENDIX D

FINAL DATA SUMMARY

Silicon, NPN Transistor - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0	8.594	25.0	1.5	2.0	0.3	1.0	1.0	18	0.1065	0.0047	0.007	0.67
1*	1.606	25.0	1.5	0.4	1.0	1.0	2.0	19			0.009	
0*	0.005	40.0	1.5	0.4	0.3	1.0	1.0	20			0.007	
4	11623.7	1.0	1.5	0.2	0.3	1.0	1.0	21	0.0005	0.005	0.007	0.71
36	180.661	5.0	1.5	2.0	1.0	1.0	2.0	22	0.2114	0.0070	0.007	1.0
0*	5.86	5.0	1.5	0.4	1.0	1.0	1.5	23			0.007	
120	116.285	5.0	1.5	10.0	1.0	1.2	1.0	24	1.0625	0.0118	0.013	0.91
0*	0.361	25.0	1.5	2.0	0.3	1.0	1.0	25			0.018	
0*	1.25	25.0	1.5	0.4	1.0	1.0	1.0	26			0.007	
0*	0.117	25.0	1.5	0.4	0.3	1.0	1.0	27			0.007	
0*	0.131	25.0	1.5	10.0	0.3	1.0	3.0	28			0.007	
0	257.709	1.0	1.5	0.4	1.0	1.0	1.0	29	0.0036	0.0059	0.007	0.84
8	3290.54	25.0	1.5	2.0	1.0	1.0	1.0	30	0.0029	0.00003	0.007	†
1	111.655	5.0	1.5	2.0	0.3	1.0	1.0	31	0.018	0.004	0.010	0.4
0*	0.061	1.0	1.5	0.4	1.0	1.2	1.0	32			0.005	
0*	3.018	5.0	1.5	2.0	1.0	1.0	1.0	33			0.010	
2	9.6	5.0	1.5	2.0	1.0	1.0	2.0	34	0.323	0.010	0.010	1.0
0	6.44	5.0	1.5	2.0	1.0	1.0	1.0	35	0.142	0.0095	0.010	0.95
0*	0.153	25.0	1.5	10.0	1.5	1.0	2.5	36			0.018	
0*	7.878	1.0	1.5	0.4	1.0	1.0	2.5	37			0.005	
6*	53.278	25.0	0.7	0.4	1.0	1.0	1.0	38			0.011	

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Silicon, NPN Transistor - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	0.017	40.0	0.7	0.4	1.0	1.0	1.0	39			0.007	
0	6071.57	1.0	0.7	2.0	1.0	1.0	1.0	40	0.00015	0.001	0.007	†
1060	11271.3	5.0	0.7	2.0	1.0	1.0	2.0	41	0.0948	0.0067	0.010	0.67
3	214.862	5.0	0.7	0.4	1.0	1.0	1.1	42	0.0194	0.0126	0.011	1.1
0*	3.564	5.0	0.7	0.2	1.0	1.0	1.0	43			0.007	
0	4.673	25.0	0.7	2.0	1.0	1.0	1.0	44	0.1958	0.0056	0.018	0.31
0*	8.205	25.0	0.7	0.4	1.0	1.0	1.0	45			0.010	
0*	8.126	25.0	0.7	10.0	1.0	1.0	1.0	46			0.018	
0*	0.77	25.0	0.7	0.4	1.0	1.0	1.0	47			0.006	
0*	31.032	1.0	0.7	0.4	1.0	1.0	1.0	48			0.005	
16	3901.74	25.0	0.7	2.0	1.0	1.0	1.0	49	0.0045	0.0001	0.006	†
0*	9.476	25.0	0.7	0.4	1.0	1.0	1.0	50			0.006	
0*	106.605	25.0	0.7	10.0	1.0	1.0	1.0	51	0.0036	0.00005	0.006	†
0*	0.092	25.0	1.0	0.4	1.0	1.0	1.0	52			0.006	
0*	8.388	40.0	1.0	0.2	1.0	1.0	1.0	53			0.009	
0*	7.546	1.0	1.0	0.2	1.0	1.0	1.0	54			0.017	
1771	1893.75	5.0	1.0	10.0	1.0	1.0	2.5	55	0.9412	0.0075	0.008	0.94
1713	3151.0	5.0	1.0	20.0	1.0	1.0	1.0	56	0.5472	0.0055	0.013	0.42
0*	0.195	25.0	1.0	10.0	1.0	1.0	1.0	57			0.018	
1*	318.456	1.0	1.0	0.4	1.0	1.0	1.0	58			0.006	

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Silicon, NPN Transistor - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No	60% λ ob	60% λ bob	λ_b Predicted	Observed/Predicted
36	2785.88	25.0	1.0	2.0	1.0	1.0	1.0	59	0.0137	0.0003	0.007	†
8**	469.58	5.8	0.85	0.58	1.0	1.0	1.0		0.020	0.007	0.007	1.0
TOTALS												
4754	29318.0											0.68

**Composite calculation.
†This entry has been deleted from the data base.

Silicon, PNP Transistor - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0	4.564	25.0	1.0	2.0	1	1.0	1.0	70	0.200	0.004	0.011	0.36
1*	3.839	5.0	1.5	2.0	1	1.0	1.0	71			0.015	
0*	0.149	25.0	1.5	0.4	1	1.0	1.5	72			0.019	
0*	0.001	40.0	1.5	0.4	1	1.0	1.0	73			0.010	
2	3743.24	1.0	1.5	0.2	1	1.0	1.0	74	0.0008	0.003	0.011	0.27
16	27.126	5.0	1.5	2.0	1	1.0	3.0	75	0.653	0.0145	0.015	0.97
0*	0.901	5.0	1.5	0.4	1	1.0	1.5	76			0.013	
7	9.1	5.0	1.5	10.0	1	1.2	1.5	77	0.923	0.012	0.021	0.58
0*	0.306	25.0	1.5	2.0	1	1.0	1.0	78			0.030	
0*	0.417	25.0	1.5	0.4	1	1.0	5.0	79			0.025	
0*	0.146	25.0	1.5	10.0	1		1.0	80			0.019	
0*	0.127	25.0	1.5	0.4	1		2.0	81			0.010	
0*	0.045	25.0	1.5	10.0	1		5.0	82			0.010	
0*	0.406	1.0	1.5	0.4	1		1.0	83			0.008	
0	300.863	25.0	1.5	2.0	1		1.0	84	0.003	0.00004	0.010	†
0	26.059	25.0	1.5	10.0	1		1.0	85	0.035	0.00009	0.010	†
0	12.07	5.0	1.5	2.0	1		1.0	86	0.075	0.005	0.015	0.33
0*	0.061	1.0	1.5	0.4	1	1.2	1.0	87			0.006	
0	409.837	25.0	1.5	2.0	1		1.0	88	0.002	0.0003	0.009	†
0	2.902	5.0	1.5	2.0	1		2.0	89	0.315	0.011	0.015	0.73
0*	2.486	25.0	0.7	0.4	1	1.0		90			0.017	

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.

†This entry has been deleted from the data base.

Silicon, PNP Transistor - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	0.539	40.0	0.7	0.4	1	1.0	1.5	91			0.010	
2	2973.1	1.0	0.7	0.2	1	1.0	1.0	92	0.001	0.007	0.011	0.64
317	5254.4	5.0	0.7	2.0	1	1.0	1.0	93	0.061	0.0088	0.015	0.59
0*	11.094	5.0	0.7	0.4	1	1.0	1.0	94			0.012	
0*	0.285	5.0	0.7	0.2	1	1.0	1.0	95			0.010	
0	5.825	25.0	0.7	2.0	1	1.0	1.0	96	0.157	0.005	0.022	0.23
1*	1.416	25.0	0.7	0.4	1	1.0	1.0	97			0.010	
0*	0.122	25.0	0.7	10.0	1	1.0	1.0	98			0.030	
0*	0.468	25.0	0.7	0.4	1	1.0	1.0	99			0.009	
0	107.641	1.0	0.7	0.4	1	1.0	2.0	100	0.0085	0.015	0.021	0.72
18	1454.57	25.0	0.7	2.0	1	1.0	1.0	101	0.0136	0.0004	0.009	†
0	35.535	25.0	0.7	10.0	1	1.0	1.0	102	0.0257	0.00015	0.010	†
0*	9.205	5.0	0.7	2.0	1	1.0	1.0	103			0.015	
0*	0.099	25.0	0.7	0.4	1	1.0	1.0	104			0.010	
0*	3.78	40.0	0.7	0.4	1	1.0	1.0	105			0.015	
0*	125.372	1.0	0.7	0.2	1	1.0	1.0	106			0.011	
978	1140.42	5.0	1.0	10.0	1	1.0	1.5	107	0.8652	0.011	0.013	0.85
1103	1936.0	5.0	1.0	20.0	1	1.0	1.0	108	0.5745	0.006	0.021	0.29
0	388.89	1.0	1.0	0.4	1	1.0	1.0	109	0.002	0.005	0.006	0.83
13	1374.84	25.0	1.0	2.0	1	1.0	1.5	110	0.0106	0.0001	0.010	†

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Silicon, PNP Transistor - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
2**	161.4	3.1	1.0	0.4	1	1.0	1.1		0.0192	0.014	0.015	0.93
TOTALS												
2427	15766.0											0.52

**Composite calculation.
†This entry has been deleted from the data base.

Germanium Transistors - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed/Predicted
0	0.059	25.0	1.0	2.0	1	1	1.0	15				
6	4.051	5.0	0.7	2.0	1	1	1.5	16	1.814	0.172	0.075	2.3
6	1632.22	25.0	0.7	2.0	1	1	1.0	17	0.0045	0.00013	0.023	†
0	0.234	25.0	1.0	2.0	1	1	1.0	60			0.012	
0	7.998	5.0	1.5	2.0	1	1	1.5	61	0.1144	0.005	0.009	0.56
0	0.013	1.0	1.5	0.4	1	1	2.5	62			0.006	
0	393.254	25.0	1.5	2.0	1	1	1.1	63	0.0023	0.00003	0.010	†
0	7.681	5.0	0.7	2.0	1	1	1.5	64	0.119	0.011	0.011	1.0
0	0.095	5.0	0.7	0.4	1	1	5.0	65			0.007	
0	0.209	25.0	0.7	2.0	1	1	5.0	66			0.031	
0	0.612	25.0	0.7	10.0	1	1	5.0	67			0.031	
0	0.039	25.0	0.7	0.4	1	1	5.0	68			0.009	
10	416.944	25.0	0.7	2.0	1	1	5.0	69	0.0276	0.00016	0.009	†

†This entry has been deleted from the data base.

Field Effect Transistors - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	2.264	1.0	1	0.2	-	1.0	-	1			0.044	
443	364.0	5.0	1	10.0	-	1.0	-	2	1.2338	0.0247	0.036	0.69
372	231.0	5.0	1	20.0	-	1.0	-	3	1.6349	0.0164	0.036	0.45
1*	0.021	25.0	1	10.0	=	1.0	-	4			0.052	
1*	1.019	25.0	1	20.0	-	1.0	-	5			0.021	
3	630.2	1.0	1	0.4	-	1.0	-	6	0.00663	0.011	0.015	0.73
5	45.978	25.0	1.5	2.0	-	1.0	-	7	0.137	0.0027	0.019	0.14
8	28.99	5.0	1	10.0	-	1.0	-	8	0.326	0.0065	0.017	0.38
0*	2.64	5.0	1	2.0	-	1.0	-	9			0.020	
0*	0.042	25.0	1	2.0	-	1.0	-	10			0.019	
0*	0.021	25.0	1	10.0	-	1.0	-	11			0.019	
0*	0.307	1.0	1	0.2	-	1.0	-	12			0.012	
0*	0.050	1.0	1	0.4	-	1.2	-	13			0.012	
0*	0.025	1.0	1	0.4	-	1.0	-	14			0.012	
2**	6.39	6.8	1	4.2	-	1.0	-		0.486	0.017	0.027	0.63
TOTALS												
833	1306.6											0.64

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
**Composite calculation.

Unijunction Transistor - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	$\frac{\text{Observed}}{\text{Predicted}}$
0*	0.149	25.0	-	1.6	-	-	-	111			0.040	
4	19.287	5.0	-	8.0	-	-	-	112	0.2722	0.0068	0.020	0.34
0*	0.597	5.0	-	1.6	-	-	-	113			0.040	
0*	0.031	25.0	-	40.0	-	-	-	114			0.020	
0*	0.051	25.0	-	8.0	-	-	-	115			0.022	
0*	1.725	5.0	-	1.6	-	-	-	116			0.010	
0**	2.553	6.8	-	2.2	-	-	-		0.359	0.024	0.019	†

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Silicon Diodes - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	1.9	1.0	1.0	1.0	0.7	1	-	13			0.0013	
0*	0.2938	25.0	1.5	1.0	0.7	1	2.0	14			0.003	
0*	0.0007	40.0	1.5	1.0	0.7	1	2.0	15			0.002	
0*	12.073	1.0	1.5	0.5	0.7	1	4.0	16			0.007	
15	205.505	5.0	1.5	5.0	0.7	1	1.5	17	0.08126	0.002	0.002	1.0
5	2673.87	5.0	1.5	1.0	0.7	1	1.5	18	0.00236	0.0003	0.003	0.1
700	1956.6	5.0	1.5	25.0	0.7	1	2.0	19	0.06158	0.0014	0.0052	0.26
0	1.752	25.0	1.5	5.0	0.7	1	4.0	20	0.52226	0.0010	0.0082	0.12
0	2.249	25.0	1.5	1.0	0.7	1	10.0	21	0.40685	0.0015	0.002	0.77
0*	0.021	25.0	1.5	25.0	0.7	1	4.0	22			0.0082	
0*	0.007	25.0	1.5	5.0	0.7	1	-	23			0.0082	
0*	45.426	1.0	1.5	1.0	0.7	1	4.0	24			0.0013	
2	1620.4	25.0	1.5	5.0	0.7	1	1.5	25			0.0015	†
0*	1.5	25.0	1.5	5.0	0.7	1	-	26			0.002	
0*	0.255	5.0	1.5	1.0	0.7	1	4.0	27			0.0013	
0*	0.105	25.0	1.5	1.0	0.7	1	4.0	28			0.0015	
0*	1.548	1.0	1.5	1.0	0.7	1	1.5	29			0.0009	
0*	0.008	25.0	1.0	-	0.7	1	1.0	30			0.003	
0*	0.290	25.0	1.0	1.0	0.7	1	1.0	31			0.002	
0*	0.038	40.0	1.0	1.0	0.7	1	1.0	32			0.002	
0	3001.02	1.0	1.0	0.5	0.7	1	1.0	33	0.0003	0.0009	0.0023	0.39

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Silicon Diodes - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed/Predicted
90	11246.2	5.0	1.0	5.0	0.7	1	1.0	34	0.0083	0.0005	0.0013	0.36
21	1305.21	5.0	1.0	1.0	0.7	1	1.0	35			0.002	†
0*	1.568	5.0	1.0	0.5	0.7	1	-	36			0.002	
635	5667.4	5.0	1.0	25.0	0.7	1	1.0	37	0.1133	0.0013	0.005	0.26
0*	32.4786	25.0	1.0	5.0	0.7	1	1.0	38			0.0082	
2*	5.747	25.0	1.0	1.0	0.7	1	1.0	39			0.002	
0	15.84	25.0	1.0	5.0	0.7	1	1.0	40	0.0577	0.00066	0.0023	0.28
0*	2.834	25.0	1.0	1.0	0.7	1	1.0	41			0.0015	
0*	410.173	1.0	1.0	1.0	0.7	1	1.0	42			0.0017	
32	11842.6	25.0	1.0	5.0	0.7	1	1.0	43			0.0015	†
0	4.738	25.0	1.0	25.0	0.7	1	1.0	44	0.19312	0.0005	0.0015	0.33
14	7301.25	25.0	1.0	5.0	0.7	1	1.5	45			0.0025	†
5	3132.05	5.0	0.6	5.0	1.0	1	-	46			0.0035	†
4	2472.75	5.0	0.6	1.0	1.0	1	1.0	47			0.004	†
0*	0.5	25.0	0.6	5.0	1.0	1	-	48			0.002	
0*	1.416	25.0	0.6	1.0	1.0	1	-	49			0.002	
0*	10.8	1.0	0.6	1.0	1.0	1	1.0	50			0.0009	
1	81.326	5.0	1.5	5.0	1.0	1	-	51	0.0248	0.0007	0.0035	0.2
1*	1.99	5.0	1.5	1.0	1.0	1	-	52			0.004	
1*	0.673	5.0	5.0	1.0	1.0	1	-	53			0.006	

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.

†This entry has been deleted from the data base.

Silicon Diodes - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed/Predicted
4**	528.3	1.5	1.2	1.2	1.0	1	1.3		0.010	0.0035	0.003	1.15
TOTALS												
1450	25386.0											0.33

**Composite calculation.

Zener Diodes - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
0*	0.181	25.0	1	1.0	-	-	-	55			0.005	
0*	0.013	40.0	1	1.0	-	-	-	56			0.006	
7	40409.3	1.0	1	0.5	-	-	-	57	0.0002	0.0004	0.0044	†
40	608.1	5.0	1	5.0	-	-	-	58	0.0696	0.0028	0.0055	0.5
5	150.284	5.0	1	1.0	-	-	-	59	0.0419	0.008	0.006	1.3
0*	0.570	5.0	1	0.5	-	-	-	60			0.004	
730	1465.59	5.0	1	25.0	-	-	-	61	0.5033	0.004	0.0068	0.59
4	6.917	25.0	1	5.0	-	-	-	62	0.7590	0.006	0.0094	0.65
0*	2.665	25.0	1	1.0	-	-	-	63			0.0052	
0	3.557	25.0	1	5.0	-	-	-	64	0.2572	0.002	0.0050	0.45
0*	1.054	25.0	1	1.0	-	-	-	65			0.0042	
0*	58.161	1.0	1	1.0	-	-	-	66			0.0039	
29	2681.7	25.0	1	5.0	-	-	-	67			0.0037	†
0	30.797	25.0	1	25.0	-	-	-	68			0.0037	†
1	592.923	25.0	1	25.0	-	-	-	69			0.0044	†
1*	2.983	5.0	1	1.0	-	-	-	70			0.006	
1**	65.62	1.5	1	1.0					0.0308	0.020	0.004	†
TOTALS												
779	2235.0											0.61

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.
†This entry has been deleted from the data base.

Miscellaneous - Data Summary

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
Thyristors												
0*	4.527	1.0	-	0.5	-	-	-	71			0.010	
12*	141.278	5.0	-	5.0	-	-	-	72			0.0022	
19*	24.649	5.0	-	1.0	-	-	-	73			0.0025	
109*	57.0	5.0	-	25.0	-	-	10.0	74			0.0039	
27*	26.0	5.0	-	50.0	-	-	10.0	75			0.0039	
0*	0.035	25.0	-	5.0	-	-	1.0	76			0.0024	
0*	0.052	25.0	-	25.0	-	-	3.0	77			0.0024	
0*	0.181	25.0	-	25.0	-	-	-	78			0.0024	
TOTALS												
167	253.65	5.0	-	13.6	-	-	3.2		0.6743	0.003	0.003	1.0
Tunnel Diodes												
1	3.406	5.0	-	5.0	-	-	-	79			0.034	
0	1.545	1.0	-	1.0	-	-	-	80			0.022	
TOTALS												
1	4.95	3.75	-	3.75	-	-	-		0.408	0.029	0.030	0.97

*No failure rate was calculated for this entry. It is included in the composite calculation indicated by **.

Miscellaneous - Data Summary (continued)

Survey Data - Sorted and Summarized by Device Type and by π Factor									Calculated from Survey Data		Predicted by Applications	Variance Ratio
Failures	Operating Hours X 10^6	π_E	π_A	π_Q	π_{S2}	π_C	π_R	LOG No.	60% λ ob	60% λ bob	λ_b Predicted	Observed / Predicted
Varactors												
0	1.718	5.0	-	5.0	-	-	-	81			0.032	
0	20.026	1.0	-	1.0	-	-	-	82			0.032	
TOTALS												
0	21.74	1.32	-	1.32	-	-	-		0.042	0.042	0.032	0.75
Schottkey Diodes											(Group VI)	
0	1.503	5.0	-	5.0	-	-	-	8			0.003	
0	4.917	5.0	-	1.0	-	-	-	9			0.002	
85	351.0	5.0	-	25.0	-	-	-	10			0.0039	
0	0.435	1.0	-	1.0	-	-	-	11			0.0012	
TOTALS												
85	357.8	5.0	-	24.5	-	-	-		0.246	0.002	0.0035	0.57

ADDENDUM

REPLACEMENT PAGES FOR
SECTION 2.2 DISCRETE SEMICONDUCTORS
OF MIL-HDBK-217B

2.2 DISCRETE SEMICONDUCTORS

The semiconductor transistors and diodes section has been revised to present the failure rate data on the basis of ambient or case temperature rather than normalized temperature and includes the effect of various quality grades and adjustment factors on the failure rate. An analytical model of the failure rate is also presented.

The applicable MIL specification for transistors and diodes is MIL-S-19500. The quality levels (JAN, JANTX, JANTXV) are as defined in MIL-S-19500.

The general failure rate model for transistors and diodes is:

$$\lambda_P = \lambda_b(\Pi_E \times \pi_A \times \pi_Q \times \pi_{S2} \times \pi_C \times \pi_R) \text{ failures}/10^6 \text{ hours}$$

where the various factors are defined in Section 1.

The various types of semiconductors require different failure rate models that vary to some degree from the basic model. The semiconductor generic groups are shown in Table 2.2-1. The specific failure rate model and the π factor values for each group are shown in the section dealing with that group.

TABLE 2.2-1
DISCRETE SEMICONDUCTOR GENERIC GROUPS

Part Type		Group
A. Transistors		
Silicon NPN Silicon PNP	Germanium PNP Germanium NPN	I
Field Effect Transistors		II
Unijunction		III
B. Diodes and Rectifiers		
Silicon (General)	Germanium (General)	IV
Voltage Regulator (Zener, Avalanche) Voltage Reference (Temp. Comp. Zener, Avalanche)		V
Thyristors		VI
C. Microwave Semiconductors and Special Devices		
Detectors	Mixers	VII
Varactors	Step Recovery Tunnel	VIII
Microwave Transistors		IX *

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The equation for the base failure rate, λ_b, is:

$$\lambda_b = Ae^{\left(\frac{N_T}{273 + T + (\Delta T)\, S}\right)} e^{\left(\frac{273 + T + (\Delta T)\, S}{T_M}\right)^P}$$

where

A is a failure rate scaling factor.

e is the natural logarithm base, 2.718

N_T, T_M and P are shaping parameters.

T is the operating temperature in degrees C, ambient or case, as applicable (see Section 2.2.9 for instructions).

ΔT is the difference between maximum allowable temperature with no junction current or power (total derating) and the maximum allowable temperature with full rated junction current or power.

S is the stress ratio of operating electrical stress to rated electrical stress (see Section 2.2.9 for S calculation).

The values for the constant parameters are shown in Table 2.2-2. The resulting base failure rates as functions of temperature and electrical stress are shown in tables for each part type in Sections 2.2.1 through 2.2.8. These tables are based on the typical maximum junction temperatures (fully derated) of 100 degrees C for germanium (70 degrees C for microwave types) and 175 degrees C for silicon (150 degrees C for microwave types) as well as a value of 25 degrees C for the maximum temperature at which full rated operation is permitted. If device temperature ratings are different from these values, see Section 2.2.9 for S calculations to compensate for these differences.

The base failure rate tables contain failure rates up to full rated conditions. If a particular operating condition of S and T is high enough to fall into a blank portion of the table, the device is overstressed, and a device with greater power rating should be selected for the application.

TABLE 2.2-2
DISCRETE SEMICONDUCTOR BASE FAILURE RATE PARAMETERS

Group	Part Type	λ_b Constants A	N_T	T_M	P	ΔT
Transistors						
I	Si, NPN	0.13	-1052	448	10.5	150
I	Si, PNP	0.45	-1324	448	14.2	150
I	Ge, PNP	6.5	-2142	373	20.8	75
I	Ge, NPN	21.	-2221	373	19.0	75
II	FET	0.52	-1162	448	13.8	150
III	Unijunction	3.12	-1779	448	13.8	150
Diodes						
IV	Si, Gen. Purp.	0.9	-2138	448	17.7	150
IV	Ge, Gen. Purp.	126	-3568	373	22.5	75
V	Zener/Avalanche	0.04	-800	448	14	150
VI	Thyristors	0.82	-2050	448	9.6	150
VII	Microwave					
VII	Ge, Detectors	0.33	-477	343	15.6	45
VII	Si, Detectors	0.14	-392	423	16.6	125
VII	Ge, Mixers	0.56	-477	343	15.6	45
VII	Si, Mixers	0.19	-394	423	15.6	125
VIII	Varactor, Step Recovery & Tunnel	.93	-1162	448	13.8	150
Transistors IX	Microwave	See Section 2.2.9				

*

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DISCRETE SEMICONDUCTORS
CONVENTIONAL TRANSISTORS

2.2.1 Transistors, Group I

SPECIFICATION	DESCRIPTION
MIL-S-19500	Si, NPN
	Si, PNP
	Ge, PNP
	Ge, NPN

Part failure rate model (λ_P):

$$\lambda_P = \lambda_b (\pi_E \times \pi_A \times \pi_Q \times \pi_R \times \pi_{S_2} \times \pi_C) \text{ failures}/10^6 \text{ hours}$$ *

where the factors are shown in Tables 2.2.1-1 through 10. *

TABLE 2.2.1-1
π_E FOR GROUP I TRANSISTORS

Environment	G_B	S_F	G_F	N_S	A_{IT}	A_{UT}	G_M	N_U	A_{IF}	A_{UF}	M_L
π_E	1	1	5	10	12	20	25	25	25	40	40

TABLE 2.2.1-2
π_A FOR GROUP I TRANSISTORS

Application	π_A
Linear	1.5
Logic Switch	0.7
High Frequency (freq. > 400 MHz and aver. power <300 mw.)	5.0

TABLE 2.2.1-3
π_Q, FOR QUALITY FACTOR

Quality Level	π_Q
JANTXV	0.12
JANTX	0.24
JAN	1.2
Lower*	6.0
Plastic**	12.0

*Hermetic packaged devices. *
**Devices sealed or encapsulated with organic materials.

TABLE 2.2.1-4
π_R FOR GROUP I TRANSISTORS

Power Rating (watts)	π_R
≤ 1	1
> 1 to 5	1.5
> 5 to 20	2.0
> 20 to 50	2.5
> 50 to 200	5.0

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TABLE 2.2.1-5

π_{S2} FOR GROUP I TRANSISTORS

$$\text{Voltage Stress, } S_2 = \frac{\text{Applied } (V_{CE})}{\text{Rated } (V_{CEO})} \times 100$$

S_2 (percent)	π_{S_2} *
100	3.0
90	2.25
80	1.65
70	1.2
60	0.88
50	0.64
40	0.48
30	0.36
20	0.30
10	0.30
0	0.30

*- $\pi_{S2} = 0.14(10)^{(.0133)S_2}$ for $S_2 \geq 22$

$\pi_{S2} = 0.3$ for $S_2 < 22$

TABLE 2.2.1-6

π_C FOR GROUP I TRANSISTORS

Complexity (1)	π_C
Single Transistor	1.0
Dual (Unmatched)	0.7
Dual (Matched)	1.2
Darlington	0.8
Dual Emitter	1.1
Multiple Emitter	1.2
Complementary Pair	0.7

(1) Each transistor in a case must be treated individually for complexity factor. Its failure rate, λ_b, modified by other π factors and then multiplied by this complexity factor. If only one transistor of a pair is used, treat as an independent item with $\pi_C = 1.0$.

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*

TABLE 2.2.1-7
MIL-S-19500 TRANSISTORS, GROUP I, SILICON, NPN
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0034	.0041	.0048	.0057	.0067	.0079	.0095	.011	.014	.018
10	.0038	.0046	.0054	.0064	.0075	.0089	.010	.013	.017	.023
20	.0043	.0051	.0060	.0071	.0084	.010	.012	.015	.020	.029
25	.0046	.0054	.0064	.0075	.0089	.010	.013	.017	.023	.033
30	.0048	.0057	.0067	.0079	.0095	.011	.014	.018	.025	
40	.0054	.0064	.0075	.0089	.010	.013	.017	.023	.033	
50	.0060	.0071	.0084	.010	.012	.015	.020	.029		
55	.0064	.0075	.0089	.010	.013	.017	.023	.033		
60	.0067	.0079	.0095	.011	.014	.018	.025			
65	.0071	.0084	.010	.012	.015	.020	.029			
70	.0075	.0089	.010	.013	.017	.023	.033			
75	.0079	.0095	.011	.014	.018	.025				
80	.0084	.010	.012	.015	.020	.029				
85	.0089	.010	.013	.017	.023	.033				
90	.0095	.011	.014	.018	.025					
95	.010	.012	.015	.020	.029					
100	.010	.013	.017	.023	.033					
105	.011	.014	.018	.025						
110	.012	.015	.020	.029						
115	.013	.017	.023	.033						
120	.014	.018	.025							
125	.015	.020	.029							
130	.017	.023	.033							
135	.018	.025								
140	.020	.029								
145	.023	.033								
150	.025									
155	.029									
160	.033									

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TABLE 2.2.1-8
MIL-S-19500 TRANSISTORS, GROUP I, SILICON, PNP
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0045	.0057	.0070	.0085	.010	.012	.014	.018	.022	.030
10	.0053	.0065	.0080	.0096	.011	.013	.016	.021	.027	.039
20	.0061	.0075	.0091	.010	.013	.015	.019	.024	.034	.053
25	.0065	.0080	.0096	.011	.013	.016	.021	.027	.039	.063
30	.0070	.0085	.010	.012	.014	.018	.022	.030	.045	
40	.0080	.0096	.011	.013	.016	.021	.027	.039	.063	
50	.0091	.010	.013	.015	.019	.024	.034	.053		
55	.0096	.011	.013	.016	.021	.027	.039	.063		
60	.010	.012	.014	.018	.022	.030	.045			
65	.010	.013	.015	.019	.024	.034	.053			
70	.011	.013	.016	.021	.027	.039	.063			
75	.012	.014	.018	.022	.030	.045				
80	.013	.015	.019	.024	.034	.053				
85	.013	.016	.021	.027	.039	.063				
90	.014	.018	.022	.030	.045					
95	.015	.019	.024	.034	.053					
100	.016	.021	.027	.039	.063					
105	.018	.022	.030	.045						
110	.019	.024	.034	.053						
115	.021	.027	.039	.063						
120	.022	.030	.045							
125	.024	.034	.053							
130	.027	.039	.063							
135	.030	.045								
140	.034	.053								
145	.039	.063								
150	.045									
155	.053									
160	.063									

TABLE 2.2.1-~~8~~ 9
MIL-S-19500 TRANSISTORS, GROUP I, GERMANIUM, PNP
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0031	.0038	.0046	.0056	.0067	.0080	.0095	.011	.013	.017
5	.0035	.0043	.0052	.0063	.0075	.0090	.010	.013	.016	.020
10	.0041	.0049	.0059	.0071	.0084	.010	.012	.015	.018	.025
15	.0046	.0056	.0067	.0080	.0095	.011	.013	.017	.022	.031
20	.0052	.0063	.0075	.0090	.010	.013	.016	.020	.027	.041
25	.0059	.0071	.0084	.010	.012	.015	.018	.025	.035	.056
30	.0067	.0080	.0095	.011	.013	.017	.022	.031	.047	
35	.0075	.0090	.010	.013	.016	.020	.027	.041		
40	.0084	.010	.012	.015	.018	.025	.035	.056		
45	.0095	.011	.013	.017	.022	.031	.047			
50	.010	.013	.016	.020	.027	.041				
55	.012	.015	.018	.025	.035	.056				
60	.013	.017	.022	.031	.047					
65	.016	.020	.027	.041						
70	.018	.025	.035	.056						
75	.022	.031	.047							
80	.027	.041								
85	.035	.056								
90	.047									

*

TABLE 2.2.1-10
MIL-S-19500 TRANSISTORS, GROUP I, GERMANIUM, NPN
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0076	.0094	.011	.014	.016	.020	.024	.029	.036	.046
5	.0088	.010	.013	.015	.019	.023	.028	.034	.042	.055
10	.010	.012	.014	.018	.021	.026	.032	.039	.050	.067
15	.011	.014	.016	.020	.024	.029	.036	.046	.060	.083
20	.013	.015	.019	.023	.028	.034	.042	.055	.074	.10
25	.014	.018	.021	.026	.032	.039	.050	.067	.095	.14
30	.016	.020	.024	.029	.036	.046	.060	.083	.12	
35	.019	.023	.028	.034	.042	.055	.074	.10		
40	.021	.026	.032	.039	.050	.067	.095	.14		
45	.024	.029	.036	.046	.060	.083	.12			
50	.028	.034	.042	.055	.074	.10				
55	.032	.039	.050	.067	.095	.14				
60	.036	.046	.060	.083	.12					
65	.042	.055	.074	.10						
70	.050	.067	.095	.14						
75	.060	.083	.12							
80	.074	.10								
85	.095	.14								
90	.12									

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DISCRETE SEMICONDUCTORS
FET

2.2.2 Transistors, Group II

SPECIFICATION	DESCRIPTION	
MIL-S-19500	Silicon Field Effect Transistors	*

Part failure rate model (λ_P):

$$\lambda_P = \lambda_b \, (\pi_E \times \pi_A \times \pi_Q \times \pi_C) \text{ failures}/10^6 \text{ hours}$$

where the factors are shown in Tables 2.2.2-1 through 5.

TABLE 2.2.2-1
π_E FOR GROUP II TRANSISTORS

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UF}	40
M_L	40

TABLE 2.2.2-2
π_A FOR GROUP II TRANSISTORS

Application	π_A
Linear	1.5
Logic Switch	0.7
High Frequency (freq. > 400 MHz. + aver. power < 300 mw)	5.0

*

TABLE 2.2.2-3
π_C FOR GROUP II TRANSISTORS

Complexity	π_C
Single Device	1.0
Dual Unmatched	0.7
Dual Matched	1.2
Dual Complementary	0.7
Tetrode	1.1

TABLE 2.2.2-4
π_Q, QUALITY FACTOR

Quality Level	π_Q
JANTXV	0.12
JANTX	0.24
JAN	1.2
Lower*	6.0
Plastic**	12.0

*Hermetic packaged devices. *
**Devices sealed or encapsulated with organic materials.

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TABLE 2.2.2-5
GRP. II, FET BASE FAILURE RATE (F./10^6 HRS.)

T (°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0092	.011	.013	.016	.019	.022	.026	.031	.039	.052
10	.010	.012	.015	.018	.021	.024	.029	.036	.047	.065
20	.012	.014	.017	.020	.023	.028	.034	.043	.058	.088
25	.012	.015	.018	.021	.024	.029	.036	.047	.066	.10
30	.013	.016	.019	.022	.026	.031	.039	.052	.076	
40	.015	.018	.021	.024	.029	.036	.047	.066	.10	
50	.017	.020	.023	.028	.034	.043	.058	.088		
55	.018	.021	.024	.029	.036	.047	.065	.10		
60	.019	.022	.026	.031	.039	.052	.076			
65	.020	.023	.028	.034	.043	.058	.088			
70	.021	.024	.029	.036	.047	.066	.10			
75	.022	.026	.031	.039	.052	.076				
80	.023	.028	.034	.043	.058	.088				
85	.024	.029	.036	.047	.066	.10				
90	.026	.031	.039	.052	.076					
95	.028	.034	.043	.058	.088					
100	.029	.036	.047	.066	.10					
105	.031	.039	.052	.076						
110	.034	.043	.058	.088						
115	.036	.047	.066	.10						
120	.039	.052	.076							
125	.043	.058	.088							
130	.047	.066	.10							
135	.052	.076								
140	.058	.088								
145	.066	.10								
150	.076									
155	.088									
160	.10									

2.2.3 Transistors, Group III

SPECIFICATION	DESCRIPTION
MIL-S-19500	Unijunction

Part failure rate model (λ_P):

$$\lambda_P = \lambda_b \times \pi_E \times \pi_Q \text{ failures}/10^6 \text{ hours}$$

where the factors are shown in Tables 2.2.3-1 through 3.

TABLE 2.2.3-1
π_E FOR GROUP III TRANSISTORS

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UT}	40
M_L	40

TABLE 2.2.3-2
π_Q, QUALITY FACTOR

Quality Level	π_Q
JANTXV	0.5
JANTX	1.0
JAN	5.0
Lower*	25.0
Plastic**	50.0

*Hermetic packaged devices.
**Devices sealed or encapsulated with organic material.

Supersedes page 2.2.3-1, 20 Sep 74

TABLE 2.2.3-3
MIL-S-19500 TRANSISTORS, GROUP III, UNIJUNCTION
BASE **FAILURE RATE**, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S: .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0064	.0088	.011	.015	.019	.024	.031	.039	.052	.073
10	.0079	.010	.013	.017	.022	.028	.036	.047	.066	.095
20	.0097	.012	.016	.020	.026	.033	.043	.058	.083	.13
25	.010	.013	.017	.022	.028	.036	.047	.064	.095	.15
30	.011	.015	.019	.024	.031	.039	.052	.073	.11	
40	.013	.017	.022	.028	.036	.047	.064	.095	.15	
50	.016	.020	.026	.033	.043	.058	.083	.13		
55	.017	.022	.028	.036	.047	.064	.095	.15		
60	.019	.024	.031	.039	.052	.073	.11			
65	.020	.026	.033	.043	.058	.083	.13			
70	.022	.028	.036	.047	.064	.095	.15			
75	.024	.031	.039	.052	.073	.11				
80	.026	.033	.043	.058	.083	.13				
85	.028	.036	.047	.064	.095	.15				
90	.031	.039	.052	.073	.11					
95	.033	.043	.058	.083	.13					
100	.036	.047	.064	.095	.15					
105	.039	.052	.073	.11						
110	.043	.058	.083	.13						
115	.047	.064	.095	.15						
120	.052	.073	.11							
125	.058	.083	.13							
130	.064	.095	.15							
135	.073	.11								
140	.083	.13								
145	.095	.15								
150	.11									
155	.13									
160	.15									

AD-A050 181 MARTIN MARIETTA AEROSPACE ORLANDO FLA F/G 9/1
FAILURE RATE MATHEMATICAL MODELS FOR DISCRETE SEMICONDUCTORS.(U)
JAN 78 T W BUTLER, D F COTTRELL, W M MAYNARD F30602-76-C-0337
UNCLASSIFIED OR-14911 RADC-TR-78-3 NL

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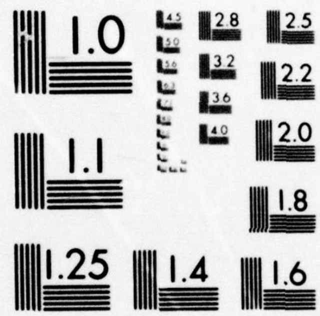

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2.2.4 Diodes, Group IV

SPECIFICATION	DESCRIPTION
MIL-S-19500	Silicon, General Purpose Germanium, General Purpose

Part failure rate model (λ_P)

$$\lambda_P = \lambda_b (\pi_E \times \pi_Q \times \pi_R \times \pi_A \times \pi_{S_2} \times \pi_C) \text{ failures}/10^6 \text{ hours}$$ *

where the factors are shown in Tables 2.2.4-1 through 8. *

TABLE 2.2.4-1
π_E FOR GROUP IV DIODES

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UF}	40
M_L	40

TABLE 2.2.4-2
π_Q, QUALITY FACTOR

Quality Level	π_Q
JANTXV	0.15
JANTX	0.3
JAN	1.5
Lower*	7.5
Plastic**	15.0

*Hermetic packaged devices. *
**Devices sealed or encapsulated with organic material.

TABLE 2.2.4-3 *
π_R FOR GROUP IV DIODES

Current Rating (amps.)	π_R
≤ 1	1
> 1 to 3	1.5
> 3 to 10	2.0
>10 to 20	4.0
>20 to 50	10.0

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TABLE 2.2.4-4 *
π_A FOR GROUP IV DIODES

Application	π_A
Small Signal (≤500 ma.)	1.0
Logic Switching	0.6
Power Rectifier (>500 ma.)	1.5
Power Rect. (H.V. Stacks) V max > 600	2.5/junction

TABLE 2.2.4-5 *
π_{S2} FOR GROUP IV DIODES

Voltage Stress, $S_2 = \frac{\text{Applied } V_R}{\text{Rated } V_R} \times 100$
V_R = diode reverse voltage.

S_2 (Percent)	π_{S2}
0 to 60	0.70
70	0.75
80	0.80
90	0.90
100	1.0

TABLE 2.2.4-6 *
π_C, CONSTRUCTION FACTOR

Contact Construction	π_C
Metallurgically Bonded	1
Non-metallurgically Bonded (Spring loaded contacts)	2

Supersedes page 2.2.4-2, 20 Sep 74

TABLE 2.2.4-7 *

MIL-S-19500 DIODES, GROUP IV, SILICON

BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0005	.0007	.0010	.0014	.0019	.0025	.0033	.0043	.0057	.0082
10	.0006	.0009	.0013	.0017	.0023	.0030	.0039	.0052	.0072	.011
20	.0008	.0012	.0016	.0021	.0027	.0036	.0047	.0064	.0095	.016
25	.0009	.0013	.0017	.0023	.0030	.0039	.0052	.0072	.011	.020
30	.0010	.0014	.0019	.0025	.0033	.0043	.0057	.0082	.013	
40	.0013	.0017	.0023	.0030	.0039	.0052	.0072	.011	.020	
50	.0016	.0021	.0027	.0036	.0047	.0064	.0095	.016		
55	.0017	.0023	.0030	.0039	.0052	.0072	.011	.020		
60	.0019	.0025	.0033	.0043	.0057	.0082	.013			
65	.0021	.0027	.0036	.0047	.0064	.0095	.016			
70	.0023	.0030	.0039	.0052	.0072	.011	.020			
75	.0025	.0033	.0043	.0057	.0082	.013				
80	.0027	.0036	.0047	.0064	.0095	.016				
85	.0030	.0039	.0052	.0072	.011	.020				
90	.0033	.0043	.0057	.0082	.013					
95	.0036	.0047	.0064	.0095	.016					
100	.0039	.0052	.0072	.011	.020					
105	.0043	.0057	.0082	.013						
110	.0047	.0064	.0095	.016						
115	.0052	.0072	.011	.020						
120	.0057	.0082	.013							
125	.0064	.0095	.016							
130	.0072	.011	.020							
135	.0082	.013								
140	.0095	.016								
145	.011	.020								
150	.013									
155	.016									
160	.020									

Supersedes page 2.2.4-3, 20 Sep 74

TABLE 2.2.4-8 *
MIL-S-19500 DIODES, GROUP IV, GERMANIUM
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0003	.0005	.0007	.0009	.0013	.0017	.0022	.0030	.0040	.0054
5	.0004	.0006	.0008	.0011	.0015	.0020	.0027	.0036	.0049	.0068
10	.0005	.0008	.0010	.0014	.0019	.0025	.0033	.0044	.0061	.0087
15	.0007	.0009	.0013	.0017	.0022	.0030	.0040	.0054	.0077	.011
20	.0008	.0011	.0015	.0020	.0027	.0036	.0049	.0068	.010	.016
25	.0010	.0014	.0019	.0025	.0033	.0044	.0061	.0087	.013	.024
30	.0013	.0017	.0022	.0030	.0040	.0054	.0077	.011	.019	
35	.0015	.0020	.0027	.0036	.0049	.0068	.010	.016		
40	.0019	.0025	.0033	.0044	.0061	.0087	.013	.024		
45	.0022	.0030	.0040	.0054	.0077	.011	.019			
50	.0027	.0036	.0049	.0068	.010	.016				
55	.0033	.0044	.0061	.0087	.013	.024				
60	.0040	.0054	.0077	.011	.019					
65	.0049	.0068	.010	.016						
70	.0061	.0087	.013	.024						
75	.0077	.011	.019							
80	.010	.016								
85	.013	.024								
90	.019									

Supersedes page 2.2.4-4, 20 Sep 74

DISCRETE SEMICONDUCTORS
ZENER AND AVALANCHE DIODES

2.2.5 Diodes, Group V

SPECIFICATION	DESCRIPTION
MIL-S-19500	Voltage Regulator and Voltage Reference (Zener & Avalanche)

Part failure rate model (λ_P):

$$\lambda_P = \lambda_b (\pi_E \times \pi_A \times \pi_Q) \text{ failures}/10^6 \text{ hours}$$

where the factors are shown in Tables 2.2.5-1 through 4.

TABLE 2.2.5-1
π_E FOR GROUP V DIODES

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UF}	40
M_L	40

TABLE 2.2.5-2
π_A FOR GROUP V DIODES

Application	π_A
Voltage Regulator	1.0
Voltage Reference (Temp. Compensated)	1.5

TABLE 2.2.5-3
π_Q, Quality Factor

Quality Level	π_Q
JANTXV	0.3
JANTX	0.6
JAN	3.0
Lower*	15.0
Plastic**	30.0

*Hermetic packaged devices. *
**Devices sealed or encapsulated with organic materials.

Supersedes page 2.2.5-1, 20 Sep 74

TABLE 2.2.5-4
MIL-S-19500 ZENER DIODES, GROUP V
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0024	.0028	.0032	.0036	.0041	.0046	.0052	.0061	.0073	.0094
10	.0027	.0031	.0035	.0039	.0044	.0050	.0058	.0068	.0086	.011
20	.0029	.0033	.0038	.0042	.0048	.0055	.0064	.0079	.010	.015
25	.0031	.0035	.0039	.0044	.0050	.0058	.0068	.0086	.011	.018
30	.0032	.0036	.0041	.0046	.0052	.0061	.0073	.0094	.013	
40	.0035	.0039	.0044	.0050	.0058	.0068	.0086	.011	.018	
50	.0038	.0042	.0048	.0055	.0064	.0079	.010	.015		
55	.0039	.0044	.0050	.0058	.0068	.0086	.011	.018		
60	.0041	.0046	.0052	.0061	.0073	.0094	.013			
65	.0042	.0048	.0055	.0064	.0079	.010	.015			
70	.0044	.0050	.0058	.0068	.0086	.011	.018			
75	.0046	.0052	.0061	.0073	.0094	.013				
80	.0048	.0055	.0064	.0079	.010	.015				
85	.0050	.0058	.0068	.0086	.011	.018				
90	.0052	.0061	.0073	.0094	.013					
95	.0055	.0064	.0079	.010	.015					
100	.0058	.0068	.0086	.011	.018					
105	.0061	.0073	.0094	.013						
110	.0064	.0079	.010	.015						
115	.0068	.0086	.011	.018						
120	.0073	.0094	.013							
125	.0079	.010	.015							
130	.0086	.011	.018							
135	.0094	.013								
140	.010	.015								
145	.011	.018								
150	.013									
155	.015									
160	.018									

2.2.6 Diodes, Group VI

SPECIFICATION	DESCRIPTION
MIL-S-19500	Thyristors

Part failure rate model (λ_p):

$$\lambda_p = \lambda_b \times \pi_Q \times \pi_E \times \pi_R \text{ failures}/10^6 \text{ hours}$$ *

where the factors are shown in Tables 2.2.6-1 through 4.

TABLE 2.2.6-1
π_E FOR GROUP VI DIODES

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UF}	40
M_L	40

TABLE 2.2.6-2
π_Q, Quality Factor

Quality Level	π_Q
JANTXV	.5
JANTX	1.0
JAN	5.0
Lower*	25.
Plastic**	50.

*Hermetic packaged devices. *
**Devices sealed or encapsulated with organic material.

TABLE 2.2.6-3
π_R FOR GROUP VI THYRISTORS *

Rated Average Forward Anode Current (amps.)	π_R
≤ 1	1
> 1 to 5	3
> 5 to 25	10
> 25 to 50	15

Supersedes Page 2.2.6-1, 20 Sep 74

*

TABLE 2.2.6-4
MIL-S-19500, GROUP VI, THYRISTORS
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.0006	.0009	.0013	.0018	.0024	.0033	.0044	.0059	.0081	.011
10	.0008	.0012	.0016	.0022	.0030	.0039	.0053	.0072	.010	.014
20	.0010	.0015	.0020	.0027	.0036	.0048	.0065	.0090	.012	.019
25	.0012	.0016	.0022	.0030	.0039	.0053	.0072	.010	.014	.022
30	.0013	.0018	.0024	.0033	.0044	.0059	.0081	.011	.017	
40	.0016	.0022	.0030	.0039	.0053	.0072	.010	.014	.022	
50	.0020	.0027	.0036	.0048	.0065	.0090	.012	.019		
55	.0022	.0030	.0039	.0053	.0072	.010	.014	.022		
60	.0024	.0033	.0044	.0059	.0081	.011	.017			
65	.0027	.0036	.0048	.0065	.0090	.012	.019			
70	.0030	.0039	.0053	.0072	.010	.014	.022			
75	.0033	.0044	.0059	.0081	.011	.017				
80	.0036	.0048	.0065	.0090	.012	.019				
85	.0039	.0053	.0072	.010	.014	.022				
90	.0044	.0059	.0081	.011	.017					
95	.0048	.0065	.0090	.012	.019					
100	.0053	.0072	.010	.014	.022					
105	.0059	.0081	.011	.017						
110	.0065	.0090	.012	.019						
115	.0072	.010	.014	.022						
120	.0081	.011	.017							
125	.0090	.012	.019							
130	.010	.014	.022							
135	.011	.017								
140	.012	.019								
145	.014	.022								
150	.017									
155	.019									
160	.022									

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2.2.7 Diodes, Group VII

SPECIFICATION	DESCRIPTION
MIL-S-19500	Microwave Detectors and Mixers, Silicon and Germanium

Part failure rate model (λ_p):

$$\lambda_p = \lambda_b \times \pi_E \times \pi_Q \text{ failures}/10^6 \text{ hours}$$

where the factors are shown in Tables 2.2.7-1 through 6.

TABLE 2.2.7-1
π_E FOR GROUP VII DIODES

Environment	π_E
G_B	1
S_F	1
G_F	10
N_S	15
A_{IT}	25
A_{UT}	40
G_M	50
N_U	50
A_{IF}	50
A_{UF}	80
M_L	200

TABLE 2.2.7-2
π_Q, QUALITY FACTOR

Quality Level	π_Q
JANTXV	1
JANTX	2
JAN	3.5
Lower *	5.

*Hermetic packaged devices.

Supersedes page 2.2.7-1, 20 Sep 74

TABLE 2.2.7-3
MIL-S-19500 DIODES, GROUP VII SILICON MICROWAVE DETECTORS
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S									
	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.035	.037	.039	.042	.044	.047	.050	.055	.062	.075
5	.036	.038	.040	.042	.045	.048	.052	.057	.066	.082
10	.037	.039	.041	.043	.046	.049	.054	.060	.072	.092
15	.038	.040	.042	.044	.047	.051	.056	.064	.078	.10
20	.038	.041	.043	.046	.049	.053	.059	.069	.087	.12
25	.039	.042	.044	.047	.050	.055	.062	.075	.098	.15
30	.040	.042	.045	.048	.052	.057	.066	.082	.11	
35	.041	.043	.046	.049	.054	.060	.072	.092	.13	
40	.042	.044	.047	.051	.056	.064	.078	.10		
45	.043	.046	.049	.053	.059	.069	.087	.12		
50	.044	.047	.050	.055	.062	.075	.098	.15		
55	.045	.048	.052	.057	.066	.082	.11			
60	.046	.049	.054	.060	.072	.092	.13			
65	.047	.051	.056	.064	.078	.10				
70	.049	.053	.059	.069	.087	.12				
75	.050	.055	.062	.075	.098	.15				
80	.052	.057	.066	.082	.11					
85	.054	.060	.072	.092	.13					
90	.056	.064	.078	.10						
95	.059	.069	.087	.12						
100	.062	.075	.098	.15						
105	.066	.082	.11							
110	.072	.092	.13							
115	.078	.10								
120	.087	.12								
125	.098	.15								
130	.11									
135	.13									

TABLE 2.2.7-4
MIL-S-19500 DIODES, GROUP VII, GERMANIUM MICROWAVE DETECTORS
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.061	.063	.066	.069	.072	.076	.080	.085	.092	.10
5	.064	.066	.069	.072	.076	.081	.086	.092	.10	.11
10	.066	.069	.073	.077	.081	.087	.093	.10	.11	.12
15	.070	.073	.077	.082	.087	.094	.10	.11	.12	.14
20	.074	.078	.082	.088	.095	.10	.11	.13	.15	.17
25	.078	.083	.089	.096	.10	.11	.13	.15	.18	.22
30	.083	.089	.097	.10	.11	.13	.15	.18		
35	.090	.098	.10	.12	.13	.15	.18			
40	.099	.10	.12	.13	.16	.19				
45	.11	.12	.14	.16	.19					
50	.12	.14	.16	.20						
55	.14	.17	.20							
60	.17	.21								
65	.21									

TABLE 2.2.7-5
MIL-S-19500 DIODES, GROUP VII, SILICON MICROWAVE MIXERS
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.047	.050	.053	.056	.060	.064	.069	.076	.086	.10
5	.049	.052	.055	.058	.061	.066	.071	.079	.092	.11
10	.050	.053	.056	.059	.063	.068	.074	.083	.099	.12
15	.051	.054	.057	.061	.065	.070	.077	.089	.10	.14
20	.052	.055	.058	.062	.067	.072	.081	.095	.12	.16
25	.053	.056	.060	.064	.069	.076	.086	.10	.13	.20
30	.055	.058	.061	.066	.071	.079	.092	.11	.15	
35	.056	.059	.063	.068	.074	.083	.099	.12	.18	
40	.057	.061	.065	.070	.077	.089	.10	.14		
45	.058	.062	.067	.072	.081	.095	.12	.16		
50	.060	.064	.069	.076	.086	.10	.13	.20		
55	.061	.066	.071	.079	.092	.11	.15			
60	.063	.068	.074	.083	.099	.12	.18			
65	.065	.070	.077	.089	.10	.14				
70	.067	.072	.081	.095	.12	.16				
75	.069	.076	.086	.10	.13	.20				
80	.071	.079	.092	.11	.15					
85	.074	.083	.099	.12	.18					
90	.077	.089	.10	.14						
95	.081	.095	.12	.16						
100	.086	.10	.13	.20						
105	.092	.11	.15							
110	.099	.12	.18							
115	.10	.14								
120	.12	.16								
125	.13	.20								
130	.15									
135	.18									

TABLE 2.2.7-6
MIL-S-19500 DIODES, GROUP VII, GERMANIUM MICROWAVE MIXERS
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T	S									
(°C)	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.10	.10	.11	.11	.12	.12	.13	.14	.15	.16
5	.10	.11	.11	.12	.13	.13	.14	.15	.17	.18
10	.11	.11	.12	.13	.13	.14	.15	.17	.19	.21
15	.11	.12	.13	.13	.14	.16	.17	.19	.21	.25
20	.12	.13	.14	.15	.16	.17	.19	.22	.25	.30
25	.13	.14	.15	.16	.17	.19	.22	.25	.30	.37
30	.14	.15	.16	.18	.20	.22	.26	.31		
35	.15	.16	.18	.20	.23	.26	.32			
40	.16	.18	.20	.23	.27	.32				
45	.18	.20	.23	.27	.33					
50	.21	.24	.28	.34						
55	.24	.29	.35							
60	.29	.36								
65	.36									

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2.2.8 Diodes, Group VIII

SPECIFICATION	DESCRIPTION
MIL-S-19500	Varactor Step Recovery Tunnel

Part failure rate model (λ_p):

$$\lambda_p = \lambda_b \times \pi_E \times \pi_Q \text{ failures}/10^6 \text{ hours}$$

where the factors are shown in Tables 2.2.8-1 through 3.

TABLE 2.2.8-1
π_E FOR GROUP VIII DIODES

Environment	π_E
G_B	1
S_F	1
G_F	5
N_S	10
A_{IT}	12
A_{UT}	20
G_M	25
N_U	25
A_{IF}	25
A_{UF}	40
M_L	40

TABLE 2.2.8-2
π_Q, QUALITY FACTOR

Quality Level	π_Q
JANTXV	.5
JANTX	1.0
JAN	5.0
Lower *	25.0

*Hermetic packaged devices. *

Supersedes page 2.2.8-1, 20 Sep 74

TABLE 2.2.8-3
MIL-S-19500 DIODES, GROUP VIII VARACTORS, STEP RECOVERY, & TUNNEL
BASE FAILURE RATE, λ_b, IN FAILURES PER 10^6 HOURS

T (°C)	S .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	.016	.020	.024	.028	.034	.040	.047	.056	.070	.093
10	.018	.022	.027	.032	.037	.044	.053	.065	.084	.11
20	.021	.025	.030	.035	.042	.050	.061	.077	.10	.15
25	.022	.027	.032	.037	.044	.053	.065	.084	.11	.18
30	.024	.028	.034	.040	.047	.056	.070	.093	.13	
40	.027	.032	.037	.044	.053	.065	.084	.11	.18	
50	.030	.035	.042	.050	.061	.077	.10	.15		
55	.032	.037	.044	.053	.065	.084	.11	.18		
60	.034	.040	.047	.056	.070	.093	.13			
65	.035	.042	.050	.061	.077	.10	.15			
70	.037	.044	.053	.065	.084	.11	.18			
75	.040	.047	.056	.070	.093	.13				
80	.042	.050	.061	.077	.10	.15				
85	.044	.053	.065	.084	.11	.18				
90	.047	.056	.070	.093	.13					
95	.050	.061	.077	.10	.15					
100	.053	.065	.084	.11	.18					
105	.056	.070	.093	.13						
110	.061	.077	.10	.15						
115	.065	.084	.11	.18						
120	.070	.093	.13							
125	.077	.10	.15							
130	.084	.11	.18							
135	.093	.13								
140	.10	.15								
145	.11	.18								
150	.13									
155	.15									
160	.18									

2.2.9 Microwave Transistors, Group IX

SPECIFICATION	DESCRIPTION
MIL-S-19500	Bipolar microwave power transistor for frequencies above 200 MHz and average power $\geq$ 300 milliwatts

The part failure rate, λ_P, is:

$$\lambda_P = \lambda_B \pi_Q \pi_A \pi_F \pi_T \pi_M \pi_E$$

where:

λ_B = 0.10 failures/10^6 hours

π_Q = quality factor, Table 2.2.9-1

π_A = application factor, Table 2.2.9-2

π_F = factor for frequency and peak operating power, Table 2.2.9-3

π_T = temperature factor, Table 2.2.9-4

π_M = matching network factor, Table 2.2.9-5

π_E = environmental factor, Table 2.2.9-6

See bibliography items 42-46 for the model background.

TABLE 2.2.9-1
π_Q, QUALITY FACTOR

QUALITY LEVEL*	π_Q*
JANTXV with IR scan for die attach and screen for barrier layer pinholes on gold metallized devices	1
JANTX or Equivalent	2
JAN or Equivalent	4
LOWER QUALITY	10

*- These quality values apply to hermetically sealed devices only, and do not apply to devices sealed or encapsulated with organic materials.

Supersedes page 2.2.9-1, 20 Sep 74

TABLE 2.2.9-2
π_A, APPLICATION FACTOR

APPLICATION	π_A
Pulse Amplifier, Duty Factor < 5%	1
Pulse Amplifier, Duty Factor ≥ 5%, ≤ 30%	2
Pulse Amplifier, Duty Factor > 30%	4
Continuous Wave	4
Oscillator	4

TABLE 2.2.9-3
π_F, FACTOR FOR OPERATING POWER AND FREQUENCY

Freq. (GHz.)	PEAK OPERATING POWER (WATTS)							
	.03 to 5	10	20	30	50	100	200	300
0.2 to 0.4	1	1	1	1	1	1	3	10
1.0	1.5	1.5	1.5	1.5	2	5	10	
1.5	1.5	1.5	1.5	1.5	3	10		
2.0	2.0	2.0	6.0	10	20			
3.0	4.0	8.0	20					
4.0	10.0	30						

Supersedes page 2.2.9-2, 20 Sep 74

TABLE 2.2.9-4. π_T, TEMPERATURE FACTOR
(See Note Below)

T (°C)	V_C/BV_{CES} for Aluminum				V_C/BV_{CES} for Refractory Metal-Gold			
	0.40	0.45	0.50	0.55	0.40	0.45	0.50	0.55
100	0.38	0.76	1.1	1.5	0.1	0.2	0.3	0.4
110	0.57	1.1	1.7	2.3	0.1	0.2	0.3	0.4
120	0.83	1.7	2.5	3.3	0.1	0.2	0.3	0.4
125	1.0	2.0	3.0	4.0	0.25	0.5	0.75	1.0
130	1.2	2.4	3.6	4.8	0.25	0.5	0.75	1.0
140	1.7	3.4	5.1	6.8	0.25	0.5	0.75	1.0
150	2.4	4.7	7.1	9.4	0.25	0.5	0.75	1.0
160	3.2	6.5	9.7	13.	0.5	1.0	1.5	2.0
170	4.4	8.7	13.	17.	0.5	1.0	1.5	2.0
180	5.8	12.	17.	23.	0.5	1.0	1.5	2.0
190	7.7	15.	23.	31.	0.5	1.0	1.5	2.0
200	10.	20.	30.	40.	0.5	1.0	1.5	2.0

NOTES:

Tabulated values of π_T are derived from the following equations:

For Aluminum, $$\pi_T = 3.96(10)^7 \left(\frac{V_C}{BV_{CES}} - .35\right) e^{-\left(\frac{5770}{T+273}\right)} \quad \text{for } 100 \le T \le 200$$

$$\pi_T = 7.58 \left(\frac{V_C}{BV_{CES}} - .35\right) \quad \text{for } T < 100$$

For Refractory Metal-Gold, $$\pi_T = 2 \left(\frac{V_C}{BV_{CES}} - .35\right) \quad \text{for } T < 125$$

$$\pi_T = 5 \left(\frac{V_C}{BV_{CES}} - .35\right) \quad \text{for } 125 \le T \le 160$$

$$\pi_T = 10 \left(\frac{V_C}{BV_{CES}} - .35\right) \quad \text{for } 160 \le T \le 200$$

where:

T is peak junction temperature (°C),
V_C is operating voltage (volts),
and BV_{CES} is collector-emitter breakdown with base shorted to emitter (volts).

Supersedes page 2.2.9-3, 20 Sep 74

TABLE 2.2.9-5
π_M, MATCHING NETWORK FACTOR

INTERNAL MATCHING	π_M
Input & Output	1
Input Only	2
No Matching	4

TABLE 2.2.9-6
π_E, ENVIRONMENTAL FACTOR

Envir.	G_B	S_F	G_F	N_S	A_{IT}	A_{UT}	G_M	N_U	A_{IF}	A_{UF}	M_L
π_E	1	1	2	2	3	4	4	6	6	8	8

Supersedes page 2.2.9-4, 20 Sep 74

2.2.10 INSTRUCTIONS FOR USE OF SEMICONDUCTOR MODELS

2.2.10.1 Device Ratings

Transistors are normally rated at maximum power dissipation and diodes at maximum current permissible. Usually each device is given two temperature rating points:

1 T_{MAX} - Maximum permissible junction temperature,

2 T_S - Maximum ambient or case temperature at which 100 percent of the rated load can be dissipated without causing the specified maximum junction temperature to be exceeded. (Case temperatures are given primarily for power devices used on heat sinks.)

As the ambient or case temperature rises above the T_S value, the internal temperature rise (i.e., the power load) must be decreased so that T_{MAX} is not exceeded. This is illustrated in Figure 2.2.10-1.

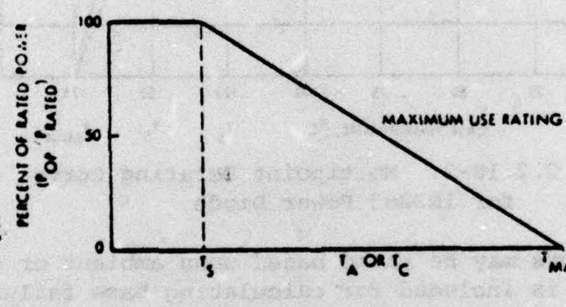

Figure 2.2.10-1. Conventional Derating Curve

Note:

T_S = temperature at which derating begins

T_{MAX} = maximum rated junction temperature

T_A = ambient temperature

T_C = case temperature

P_{OP} = actual power dissipated

P_{MAX} = maximum rated power at T_S

Maximum junction temperature (T_{MAX}) is normally 175 or 200°C for silicon and 100°C for germanium devices. Although T_S is usually 25°C, it is different for same devices (such as power devices).

Some devices have a multipoint derating curve as shown by the solid line in the example of Figure 2.2.10-2. The failure rate of a device with multipoint derating can be estimated with the present models by assuming the device to be linearly derated from T_S to T_{MAX} as shown by the dashed line. The use of this assumption will result in a predicted failure rate higher than that the device might actually experience, with the amount of error dependent upon the difference between the two rating values where T_S intersects the assumed and actual rating plots.

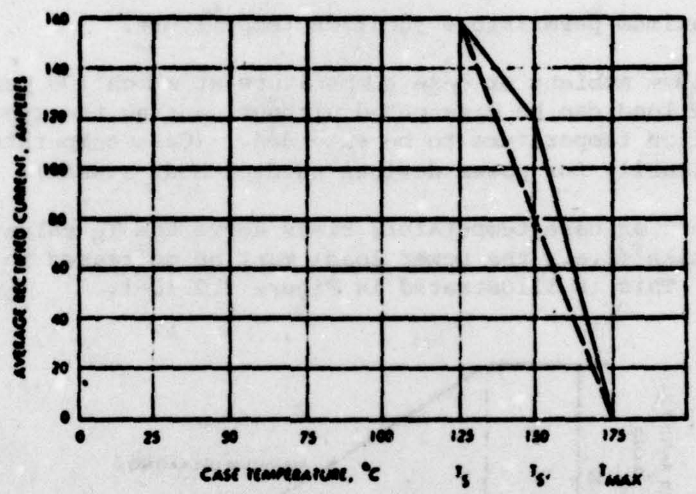

Figure 2.2.10-2. Multipoint Derating Curve
for 1N3263 Power Diode

Since semiconductors may be rated based upon ambient or case temperatures, the following guidance is included for calculating base failure rates:

1 <u>No Heat Sink Used and Ambient Rating Known</u> - Calculate stress and temperature (if necessary) per paragraph 2.2.10.2 and use base failure rate table.

2 <u>No Heat Sink Used and Only Case Rating Known</u> - If device rating based upon ambient temperature cannot be determined, calculate the base failure rate as in 1 above <u>and multiply by 10</u>.

3 <u>Heat Sink Used and Case Rating Known</u> - Calculate base failure rate as in 1 above.

4 <u>Heat Sink Used and Only Ambient Rating Known</u> - If device rating based upon case temperature cannot be determined, calculate base failure rate as in 1 above.

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2.2.10.2 Determining Appropriate Stress Ratio & Temperature. *

The base failure rate tables are based upon ambient or case temperature (T degrees C) and electrical stress råtio (S). The following instructions show the methods for calculating S. In some cases, the operating ambient or case T must be corrected before entering the failure rate tables. These corrections, where needed, are indicated in (7) below. Operating junction temperatures do not have to be calculated to use the models.

(1) Groups I, II & III Transistors.

a. Single device in case.

For Silicon, $S = \frac{P_{OP}}{P_{MAX}}$ (C.F.) For Germanium, $S = \frac{P_{OP}}{P_{MAX}}$

where:

P_{OP} = actual power dissipated

P_{MAX} = maximum rated power at T_S

C.F. = stress correction factor per (7) below

b. Dual device in single case (equally rated).

$$S = \left[\frac{P_1}{P_S} + P_2\left(\frac{2P_S - P_T}{P_T \times P_S}\right)\right] (C.F.)$$

where:

S = stress ratio of side being evaluated

P_1 = power dissipation in side being evaluated

P_2 = power dissipation in other side of device

P_S = maximum power rating at T_S of one side of the dual device with the other side not operating (one side rating)

P_T = maximum rating at T_S with both sides operating (both side rating)

<u>NOTE</u>: Specifications for dual devices in one case usually give a maximum rating for each device and a total power rating which is significantly less than the sum of individual ratings.

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C.F. = stress correction factor per (7) below for silicon

C.F. = 1.0 for germanium

(2) Groups IV & VI General Purpose Diodes & Thyristors.

For Silicon, $S = \frac{I_{OP}}{I_{MAX}}(C.F.)$ For Germanium, $S = \frac{I_{OP}}{I_{MAX}}$

where:

I_{OP} = operating average forward current

I_{MAX} = maximum rated average forward current at T_S

C.F. = stress correction factor per (7) below

(3) Group V Zener Diodes

Zener diodes are rated for maximum current or power or both. Either rating may be used as follows:

$$S = \frac{P_{OP}}{P_{MAX}}(C.F.) \quad \text{or } S = \frac{I_{Z(OP)}}{I_{Z(MAX)}}(C.F.)$$

where:

P_{OP} = actual power dissipated

P_{MAX} = maximum rated power at T_S

$I_{Z(OP)}$ = actual operating zener current

$I_{Z(MAX)}$ = maximum rated zener current at T_S

C.F. = stress correction factor per (7) below

(4) Group VII Microwave Mixer Diodes

$$S = \frac{\text{Operating Spike Leakage (ergs)}}{\text{Rated Burnout Energy at 25 degrees C}}$$

(5) Group VII Microwave Detector Diodes

$$S = \frac{P_{OP}\text{ (Operating Power Dissipation)}}{P_{MAX}\text{ (Rated Power at 25 degrees C)}}$$

Supersedes page 2.2.10-5, 20 Sep 74

(6) Group VIII Varactor, Step Recovery, and Tunnel Diodes

$$S = \frac{P_{OP}}{P_{MAX}} (C.F.)$$

where:

P_{OP} = operating power dissipated

P_{MAX} = maximum rated power at T_S

C.F. = stress correction factor per (7) below

(7) Stress Correction Factor (C.F.)

a. Devices with T_S = 25 degrees C & T_{MAX} = 175 degrees C to 200 degrees C *

C.F. = 1

b. Devices with $T_S \neq$ 25 degrees C & T_{MAX} = 175 degrees C to 200 degrees C *

$$C.F. = \frac{175 - T_S}{150}$$

c. Devices with T_S = 25 degrees C & $T_{MAX} <$ 175 degrees C *

$$C.F. = \frac{T_{MAX} - 25}{150}$$

and enter λ_b table with $T = T_A + (175 - T_{MAX})$

or $T = T_C + (175 - T_{MAX})$

d. Devices with $T_S \neq$ 25 degrees C & $T_{MAX} <$ 175 degrees C *

$$C.F. = \frac{T_{MAX} - T_S}{150}$$

and enter λ_b table with $T = T_A + (175 - T_{MAX})$

or $T = T_C + (175 - T_{MAX})$

Supersedes page 2.2.10-6, 20 Sep 74

2.2.11 Examples of Use of Semiconductor Models. *

2.2.11.1 Examples of Stress Ratio Calculations for Dual Transistors. *

Example 1.

For a 2N2060

Ratings $P_S = 0.500$ w

$P_T = 0.600$ w

Given operating conditions

Side one P = 0.1 w

Side two P = 0.4 w

For side one

$$S = \frac{P_1}{P_S} + P_2 \left(\frac{2P_S - P_T}{P_T \times P_S}\right)$$

$$S = \frac{0.1}{0.5} + 0.4 \left(\frac{2 \times 0.500 - 0.6}{0.6 \times 0.5}\right)$$

$$S = 0.2 + 0.4 \left(\frac{0.4}{0.3}\right) = 0.2 + 0.4\ (1.333)$$

$$= 0.2 + 0.5333$$

$$S = 0.733$$

For side two

$$S = \frac{0.4}{0.5} + 0.1 \left(\frac{2 \times 0.5 - 0.6}{0.6 \times 0.5}\right)$$

$$S = \frac{0.4}{0.5} + 0.1\ (1.333) = 0.8 + 0.1333$$

$$S = 0.933$$

Example 2.

For the same transistor as Example 1

Given operating conditions

Side one P = 0 w

Side two P = 0.5 w

For side one

$$S = 0 + 0.5\,(1.333) = 0.666$$

For side two

$$S = \frac{0.5}{0.5} + 0\,(1.333) = 1.0$$

Though there is no dissipation in side one, because of the heating from side two, the stress ratio is still 0.666. If one side of a dual is not connected, treat as single transistor.

<u>Example 3</u>.

For the same transistor as Example 1

Given operating conditions

Side one P = 0.300 w

Side two P = 0.300 w

For either side

$$S = \frac{0.3}{0.5} + 0.3\,(1.333)$$

$$S = 0.6 + 0.4$$

$$S = 1.0$$

2.2.11.2 Specific Steps in Computing Failure Rates, λ_P *

The generalized steps for computing a semiconductor failure rate are summarized as follows:

Step (1) Collect and summarize the values of parameters basic to prediction for the specific part type.

Step (2) Determine the appropriate adjusted stress ratio, S, and operating temperature, T. (Refer to Section 2.2.10) *

Step (3) Locate the appropriate λ_b table for the particular group and part type. Derive λ_b for the adjusted stress ratio and reference temperature.

Step (4) Locate the appropriate table for defining π_E and extract the appropriate value for the given environmental service operation.

Step (5) through Step (N-1). Locate the tables appropriate for all the other π adjustment factors and derive the various π constants.

Step (N) Perform the computation indicated in the mathematical model appropriate for the part type.

2.2.11.3 Examples of Failure Rate Calculations *

Example 1.

Step (1) Given: Silicon NPN general purpose JAN grade transistor in linear service at 0.4 of its rated maximum power of 1 watt in fixed ground installation at 30 degrees C ambient, rated for 500 mw at 25 degrees C with T_{MAX} = 175 degrees C, and operated at 60 percent of maximum voltage. *

Step (2) Stress ratio, $S = \frac{P_{OP}}{P_{MAX}}$ (C.F.) = 0.4 x 1.0 = 0.4

C.F. = 1 for T_S = 25 degrees C and T_{MAX} = 175 degrees C

Step (3) From Table 2.2.1-7 for T = 30 degrees C and S = 0.4, λ_b = 0.0079 failures/10^6 hours *

Step (4) From Table 2.2.1-1, Fixed Ground, π_E = 5

Step (5) From Table 2.2.1-2, for linear operation, π_A = 1.5

Step (6) From Table 2.2.1-3, for JAN quality level, π_Q = 1.2

Step (7) From Table 2.2.1-4, for 1 watt rating, π_R = 1.0 *

Step (8) From Table 2.2.1-5, at 60 percent of rated voltage, π_{S_2} = 1.0

Step (9) From Table 2.2.1-6, for single transistor, π_C = 1.0

Step (10) Perform the calculation:

$$\lambda_P = \lambda_b (\pi_E \times \pi_A \times \pi_Q \times \pi_R \times \pi_{S_2} \times \pi_C)$$

$$\lambda_P = 0.0079\ (5 \times 1.5 \times 1.2 \times 1.0 \times 1.0 \times 1.0)$$ *

$$\lambda_P = 0.072 \text{ failures}/10^6 \text{ hours}$$

Example 2.

Step (1) Given: Field effect transistor (FET), JANTX grade, operating at 80 milliwatts at 500 MHz in Fighter Inhabited service at 60 degrees C ambient temperature. (Rated at 200 milliwatts, T_S = 25 degrees C and T_{MAX} = 175 degrees C)

Step (2) Stress ratio, S = 80/200 = 0.4

Step (3) From Table 2.2.2-5 for T = 60 degrees C and S = 0.4, λ_b = 0.031 failures/10^6 hours

Step (4) From Table 2.2.2-1, A_{IF} environment, π_E = 25

Step (5) From Table 2.2.2-2, freq. >400 MHz, power <300 mw, π_A = 5.0 *

Step (6) From Table 2.2.2-4, JANTX grade, π_Q = 0.24

Step (7) From Table 2.2.2-3, single transistor, π_C = 1.0

Step (8) Perform the calculation:

$$\lambda_P = \lambda_b(\pi_E \times \pi_A \times \pi_Q \times \pi_C)$$

$$\lambda_P = 0.031\ (25 \times 5.0 \times 0.24 \times 1.0)$$

$$\lambda_P = 0.96 \text{ failures}/10^6 \text{ hours}$$

Example 3.

Step (1) Given: Silicon diode, JAN grade, in ground mobile service at 0.4 rated maximum current of 1 amp, operated at 30 degrees C * ambient in logic switching with 20 percent of rated voltage. Rated 50 ma at 25 degrees C with T_{MAX} = 200 degrees C and naving a metallurgically bonded contact.

Step (2) Stress ratio, S = 0.4 x 1.0 = 0.4 C.F. = 1.0 for T_S = 25 degrees C and T_{MAX} = 200 degrees C

Step (3) From Table 2.2.4-7 for S = 0.4 and T = 30 degrees C, λ_b = 0.0025 failures/10^6 hours

Step (4) From Table 2.2.4-1, ground mobile service, π_E = 25

Step (5) From Table 2.2.4-2, JAN grade, π_Q = 1.5

Step (6) From Table 2.2.4-3, for 1 amp, π_R = 1.0 *

Step (7) From Table 2.2.4-4, logic switching, π_A = 0.6

Step (8) From Table 2.2.4-5, 20 percent rated voltage, π_{S2} = 0.7

Step (9) From Table 2.2.4-6, metallurgically bonded contacts, π_C = 1.0

Step (10) Perform the calculation:

$$\lambda_P = \lambda_b\ (\pi_E \times \pi_Q \times \pi_R \times \pi_A \times \pi_{S_2} \times \pi_C)$$

$$\lambda_P = 0.0025\ (25 \times 1.5 \times 1.0 \times 0.6 \times 0.7 \times 1.0) \quad *$$

$$\lambda_P = 0.039 \text{ failures}/10^6 \text{ hours}$$

Example 4.

Step (1) Given: Silicon dual transistor (complementary), JAN grade, rated for 0.25 W. at 25 degrees C, one side only, and 0.35 W. at 25 degrees C, both sides, with T_{MAX} = 200 degrees C, operating in linear service at 50 degrees C ambient in a sheltered naval environment. Side one, NPN, operating at 0.1 W. and 50 percent of rated voltage and side two, PNP, operating at 0.05 W. and 30 percent of rated voltage.

Step (2) For side one, stress ratio,

$$S = \left[\frac{P_1}{P_S} + P_2\left(\frac{2P_S - P_T}{P_T \times P_S}\right)\right] \text{(C.F.)}$$

C.F. = 1.0 for T_S = 25 degrees C and T_{MAX} = 200 degrees C

$$S = \left[\frac{0.1}{0.25} + 0.05\left(\frac{2 \times 0.25 - 0.35}{0.35 \times 0.25}\right)\right] (1.0)$$

$S = 0.48$

Step (3) From Table 2.2.1-7, for T = 50 degrees C and S = 0.48, λ_b = 0.012 failures/10^6 hours

Step (4) From Table 2.2.1-1, naval sheltered, $\pi_E = 10$

Step (5) From Table 2.2.1-2, linear, $\pi_A = 1.5$

Step (6) From Table 2.2.1-3, JAN grade, $\pi_Q = 1.2$

Step (7) From Table 2.2.1-4, for .25 watt, $\pi_R = 1.0$ *

Step (8) From Table 2.2.1-5, at 50 percent of rated voltage, $\pi_{S_2} = 0.75$

Step (9) From Table 2.2.1-6, for complementary pair, $\pi_C = 0.7$

Step (10) Perform the calculation for side one:

$\lambda_P = \lambda_b\ (\pi_E \times \pi_A \times \pi_Q \times \pi_R \times \pi_{S_2} \times \pi_C)$

$\lambda_P = 0.012\ (25 \times 1.5 \times 1.2 \times 1.0 \times 0.75 \times 0.7)$ *

λ_P = 0.1134 failures/10^6 hours for side one

Step (11) For side two, stress ratio,

$$S = \frac{0.05}{0.25} + 0.1\left(\frac{2 \times 0.25 - 0.35}{0.35 \times 0.25}\right)$$

$S = 0.37$

Step (12) From Table 2.2.1-7, for T = 50 degrees C and S = 0.37, λ_b = 0.014 failures/10^6 hours

Step (13) π_E, π_A, π_Q, π_R and π_C same as for side one *

Step (14) From Table 2.2.1-4, at 30 percent of rated voltage, π_{S_2} = 0.36

Step (15) Perform the calculation for side two:

$$\lambda_P = \lambda_b (\pi_E \times \pi_A \times \pi_Q \times \pi_R \times \pi_{S_2} \times \pi_C)$$

$$\lambda_P = 0.014\ (10 \times 1.5 \times 1.2 \times 1.0 \times 0.36 \times 0.7)$$ *

λ_P = 0.06 failures/10^6 hours for side two

<u>Example 5</u>.

Step (1) Given: Silicon diode, JANTX grade, in fixed ground service at 0.6 rated maximum current and 40 percent rated voltage in power rectifier operation at 60 degrees C case temperature. Device rated at T_S = 100 degrees C case temperature and T_{MAX} = 150 degrees C and has a metallurgically bonded contact.

Step (2) Stress ratio, S = 0.6 (C.F.)

From Section 2.2.10.2, C.F. = $\frac{T_{MAX} - T_S}{150} = \frac{150 - 100}{150} = 0.333$

S = 0.6 x 0.333 = 0.2

Temperature for λ_b computation, $T = T_C + (175 - T_{MAX})$

$T = 60 + (175 - 150)$

$T = 85$

Step (3) From Table 2.2.4-6, for T = 85 degrees C and S = 0.2, λ_b = 0.0039 failures/10^6 hours

Step (4) From Table 2.2.4-1, fixed ground, π_E = 5

Step (5) From Table 2.2.4-2, JANTX grade, π_Q = 0.3

Step (6) From Table 2.2.4-3, power rectifier, π_A = 1.5

Step (7) From Table 2.2.4-4, at 40 percent of rated voltage, π_{S_2} = 0.7

Step (8) From Table 2.2.4-5, for metallurgically bonded contacts, π_C = 1.0

Step (9) Perform the calculation:

$$\lambda_P = \lambda_b (\pi_E \times \pi_Q \times \pi_A \times \pi_{S_2} \times \pi_C)$$

$$\lambda_P = 0.0039\ (5 \times 0.3 \times 1.5 \times 0.7 \times 1.0)$$

λ_P = 0.006 failures/10^6 hours

Example 6.

Step (1) Given: Microwave transistor, JANTX Equivalent quality, in mobile ground environment as a pulse amplifier at 20% duty factor with a power output of 30 watts at 1.5 GHz. The device package has input and output matching networks and uses refractory metal-gold metallization. V_C = 28 volts and BV_{CES} = 56 volts. The peak junction temperature is 140°C.

Step (2) From Table 2.2.9-1, JANTX Equivalent, $\pi_Q = 2$.

Step (3) From Table 2.2.9-2, pulse amplifier with 20% duty factor, $\pi_A = 2$.

Step (4) From Table 2.2.9-3, 1.5 GHz. & 30 watts, $\pi_F = 1.5$.

Step (5) $V_C/BV_{CES} = 28/56 = 0.5$. From Table 2.2.9-4, $V_C/BV_{CES} = 0.5$, $T = 140^{\circ}C$, and with refractory metal-gold metallization, $\pi_T = 0.75$.

Step (6) From Table 2.2.9-5, input and output matching networks, $\pi_M = 1$.

Step (7) From Table 2.2.9-6, mobile ground (G_M), $\pi_E = 4$.

Step (8) Perform the calculation:

$$\lambda_P = \lambda_B \, \pi_Q \, \pi_A \, \pi_F \, \pi_T \, \pi_M \, \pi_E$$

$$= 0.1 \, (2) \, 2 \, (1.5) \, 0.75 \, (1) \, 4$$

$$= 1.8 \text{ failures}/10^6 \text{ hr.}$$